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BIOGRAPHICAL SKETCH OF JESSE L. WILLIAMS, CIVIL ENGINEER.

From Stuart's "Civil and Military Engineers of America," now in press.

The professional life of the subject of this sketch has extended through a period of more than 40 years, and been connected with the rise and progress of the public works of Ohio and Indiana, and with other great enterprises which have effected important changes in the condition of the country west of the Alleghany mountains.

The aggregate length of the various lines of public works, coming under his supervision as engineer, during their location and construction, cannot, it is believed, be less than 2,500 miles. The total amount of expenditure upon these works, while under his charge, probably exceeds $20,000,000. Commencing his professional life at a time when the superior facilities afforded for the carrying on of inland trade and commerce by means of canals, were attracting attention everywhere to their construction, he will, probably, close it, as this kind of improvement is becoming secondary in importance to another of still higher perfection, the railway. Indeed, it may be said that in the regions west of the Alleghanies, he has witnessed the origin, the growth, the maturity and the decline of the canal system.

Mr. Williams was born in the State of North Carolina, in May, 1807. His parents were members of the Society of Friends, and about the year 1814, emigrated to Cincinnati, Ohio. The vicissitudes attending almost every business enterprise, at the close of the war of 1812, involved his father in pecuniary losses and prevented him from giving his son a liberal education. Although he has often been heard to regret the want of opportunities and leisure in early life for the acquisition of higher attainments in learning, yet, as tested by the demands of a long, varied and successful professional career, it would seem that his early disadvantages have been mainly overcome. His acquirements, theoretical and practical, under the guidance of a sound discriminating judgment, have been adequate to the faithful discharge of the numerous difficult and complex duties of the varied official stations in which he has been placed. He commenced his career as rodman in the corps of engineers on the Miami and Erie canal in the State of Ohio, in 1824, and subsequently had charge as assistant engineer of the heavy and difficult division next to Cincinnati during its location and construction.

In the spring of 1828, the Chief Engineer of the State of Ohio, David S. Bates, appointed Mr. Williams to locate the canal from Newark to Chillicothe, including the Columbus side-cut. After this duty was performed, the construction

of the divisions of this work between Circleville and Chillicothe was committed to his charge.

The sound judgment and the steady perseverance which marked the course of Mr. Williams in the discharge of the various difficult duties of his profession attracted public attention, and early in 1832 he was invited by the Board of Commissioners of the Wabash and Erie Canal, to take charge as Chief Engineer of the location and construction of that important work, which was then about to be commenced under the authority and control of the State of Indiana.

In 1834, Mr. Williams was appointed with William Gooding, as associate engineer, to survey the White Water Valley for the purpose of determining the practicability of constructing a canal through that valley to the Ohio river.

On the passage of the law authorizing a general system of internal improvements approved January 27th, 1836, Mr. Williams was appointed Chief Engineer of all the canals of the State, including the Wabash and Erie Canal, which, by the provisions of the new law, was extended from its original terminus at the mouth of the Tippecanoe river, to Terra Haute.

At this period of time, Mr. Williams had under his charge about 800 miles of canals, portions of which were in progress of location and construction. In September, 1837, the Chief Engineer of Railroads and Turnpikes having resigned, these works, also under like progress, were, by action of the State Board of Internal Improvements, placed under the charge of Mr. Williams. As State Engineer, his supervision then embraced more than 1300 *miles of public works.* Afterwards, when the appointing power was changed, he was elected by the Legislature to the same position, and continued therein until the office was abolished at the session of 1841; when the prosecution of the public works was entirely suspended.

Perplexing duties, and great labor and responsibilities, were necessarily attached to the position which was so long occupied by Mr. Williams, as the State Engineer of Indiana. The general direction of every survey and location, the plans of every important structure, and the letting of all contracts, came, in their order, under his immediate supervision. In the course of the summer and autumn of 1838 no less than 13 public lettings took place, by order of the Board of Internal Improvements, in different parts of Indiana, at intervals of about two weeks. With such facilities for travelling as belonged to that period, a punctual attendance at the numerous lettings and the making of necessary preparations for them, must have taxed the mental and physical energies of one man in no common measure. It was computed at the time by those who felt some interest in such matters, that the journeyings of the State Engineer, performed mainly on horseback, during the three months amounted to at least 3,000 miles. After transacting business at one place until the close of the day, the duties of his station often required his presence early next morning at another place a day's journey distant, and it has been stated that Mr. Williams on several occasions made such journeys on horseback, and through sparsely settled districts of country, between the setting and the rising of the sun. This fact illustrates, in some measure, the nature of a few of the difficulties that were encountered and overcome by the pioneer engineers in the earlier improvements of the Western States.

After the 1st of March, 1846, Mr. Williams, in addition to his duties and responsibilities as State Engineer, became, by appointment of the Legislature, ex-officio a member of the Board of Internal Improvements and Acting Commissioner of the Wabash and Erie Canal. In the discharge of the various duties of these stations, he continued to act for a period of about 2 years, having charge also of the selections, management, and sales of the canal lands. As State Engineer, the public works in every part of the State were under his charge from 1836 to 1842, and his special supervision of the Wabash and Erie Canal was continued during this period.

In 1837, Mr. Williams was appointed Chief Engineer of the Madison and Indianapolis Railroad, which position he held until 1842. The prostration of State credit that followed the financial revulsion of this year, checked the progress of public works in the United States. From 1842 to 1847, Mr. Williams was occupied in mercantile and manufacturing pursuits at Fort Wayne, the place of his residence.

Before leaving the capital of the State of Indiana, he was offered the Presidency of the Madison and Indianapolis Railroad, then about to be completed under the management of a company, the office of President and Chief Engineer being united in one. In June, 1847, Mr. Williams was appointed Chief Engineer of the Wabash and Erie Canal, resuming at that date charge of this work after 5 years retirement. He continued to occupy this position up to 1859, thus making his professional services, in connection with this important work, extend over a period of more than 22 years.

In February, 1854, Mr. Williams was appointed Chief Engineer of the Fort Wayne & Chicago Railroad, which position he held (in addition to his charge of the Wabash and Erie Canal) up to the time of the consolidation with the Pittsburgh Railroad, in 1856, and for a few months afterwards, until the work could be opened to Plymouth, and a temporary connection formed with Chicago, by the way of the Michigan Southern & Northern Indiana Railroad. Since that time, excepting as a Director of the consolidated company, he has had no official connection with this work. In its first conception as a great through line to the Northwest, and in giving form and vitality to the first movements in its favor in Indiana, he bore an active and efficient part, and to this extent his friends may justly claim for him an important share in its paternity. Others carried out the idea, and to them is due the credit of accomplishing the great work, which, in connection with the Pennsylvania Central Railroad, forms one of the chief routes between Chicago and the cities on the Atlantic seaboard.

In July, 1864, Mr. Williams was appointed by President Lincoln a Director of the Union Pacific Railroad, on the part of the Government. The term being but one year under the law, he was reappointed each succeeding year until the work was completed in 1869, receiving commissions from three successive Presidents.

In the Fall of 1864, he accompanied the consulting engineer of the Company, Colonel Silas Seymour, over the first 40 miles of the route, then in progress of construction to a point on the Platte River west of Fremont. The policy adopted by the Board of making very elaborate preliminary surveys, so necessary to the selections of the very best route for this national work, was earnestly seconded by Mr. Williams, as may be seen in his able reports to the Secretary of the Interior. In July, 1867, Mr. Williams made a tour of inspection over the road to the end of the track. On the 13th of June, 1868, Mr. Williams was instructed by the Secretary of the Interior, to "examine and report specifically, as to the condition of the Union Pacific Railroad, where it has beeen constructed or surveyed." From his report to the Hon. Secretary, dated August 15th, 1868, it will be seen that this important duty was ably performed. The President of the Company accompanied him in a special train to the end of the track, then 660 miles from the Missouri River, stopping to examine every station and all important structures. At the end of the track a company of United States cavalry for protection against Indian hostilities, with twenty Government wagons for transportation, were in readiness, and the whole party, under command of General Dodge, Chief Engineer of the Company, passed thence on horseback over the entire line of surveys to Salt Lake, about four hundred miles.

The Secretary in his annual report to the President of the United States in 1868, referring to this specific examination of the Union Pacific Railroad says, "Mr. Williams is an experienced civil engineer, and performed the duty committed to him in a very satisfactory manner."

On the 19th of January, 1869, Mr. Williams was appointed Receiver of the Grand Rapids and Indiana Railroad, by the United States Court of the Western District of Michigan. This work, 320 miles long, is designed to connect the City of Fort Wayne with Little Traverse Bay and the Straits of Mackinaw. The Court, for the protection and benefit of all interests involved, ordered the Receiver to borrow money and build the road as required by law. In addition to the duties and responsibilities ordinarily belonging to a financial trust like this, Mr. Williams also took upon himself a professional charge as Chief Engineer of the work. These several duties, especially the financial, were found so exacting as to leave no time for the proper per-

formance of Pacific Railroad duties. He therefore, in October, 1869, resigned the position as Government Director of the Union Pacific Railroad, and retired with the well merited esteem of the Government for valuable services rendered.

TECHNICAL EDUCATION—THE RENSSELAER POLYTECHNIC INSTITUTE.*

The subject of scientific education never before challenged public attention as it does now. The deep interest felt in this question among our English friends, is exhibited by the space devoted to its discussion in the columns of our contemporaries across the ocean.

We can not perform our duty in the matter in a better way than to lay before our readers a large portion of the late report of a committee appointed to inquire "whether any change in the course of study of the Rensselaer Polytechnic Institute is desirable."

This institution has for many years held the foremost place among the technical schools of this country, and counts among its graduates many of our most prominent engineers.

The committee consisted of Messrs. E. Thompson Gale, Alexander L. Holley and Clarence E. Dutton. No selection could have been better; gentlemen of such varied culture, familiar with the past history of the institution, were certainly better fitted for the important task set before the committee than would have been either professional instructors or merely practical, although successful, engineers.

In the preface to the report the committee offer the following explanation:—

This report is not put forward as a complete plan for engineering instruction, or for the organization of an engineering school, but rather as preliminary to such a plan; and the committee are aware that some of their recommendations may seem revolutionary. They believe, however, that the course suggested is at least in the direction of *closing the breach between Theory and Practice*, which is universally admitted to be the weak point in all our systems of technical education. And if the experts who read this report will take the time to correct what they consider fallacious or impracticable, and to add the weight of their endorsement and the benefit of their amendments to what they consider generally good and feasible, the cause of technical education at large cannot fail to be advanced.

The following is their report:

At the commencement of their investigations the committee found themselves without definite instructions as to the range which their inquiries should cover, or the limits within which their recommendations should be confined. They therefore took the liberty of deciding these points for themselves, feeling that they had no peculiar prejudices or prepossessions to gratify, and no foregone conclusions to urge; and whatever may seem new, or revolutionary, or experimental, in their recommendations, has been developed entirely by a careful consideration of the facts brought to light by earnest study of the problems before them. They have neither courted nor shunned conclusions, but have merely followed whithersoever the facts seemed to lead. Whatever views may be taken respecting any or all the matters herein submitted, it is felt that they ought, at least, to be credited to a deep and earnest desire to benefit the Institute.

The committee seem to have been appointed in response to a conviction, widely spread among the graduates of the institution, that the courses of study pursued, embraced too large a proportion of purely theoretical instruction, and too small a proportion of technical, or practical instruction. How far such a conviction may have prevailed, your committee cannot say. But it seems quite certain that it existed among some whose opinions are entitled to great respect, and it furthermore seemed that a still larger number were convinced that the question of the relative proportions of these studies was an open one, and needed very careful in-

* From the report of a Committee of the Trustees of the Rensselaer Polytechnic Institute, concerning the System of Instruction.

vestigation. Believing that this was the question which was chiefly to engage their attention, the committee endeavored to obtain the advice of a large number of American engineers, mechanics and educators, whose high intelligence and extended reputations would give great importance to their expressions. With this view, a circular letter, accompanied by a copy of our present curriculum, was addressed to more than 60 gentlemen, known to us as possessing eminent qualifications, both by education and great practical experience in its application, to assist the committee in drawing its conclusions. The form of the letter was as follows :

"DEAR SIR :—The Trustees and Faculty of the Rensselaer Polytechnic Institute, desiring to obtain such information as will enable them to determine what course of study is best adapted to secure the aims and purposes of the institution in their charge, respectfully solicit from you an expression of opinion upon the following questions :

"1*st*. Does the course of study announced in the Catalogue (a copy of which is also sent you) embrace too great a proportion of the higher mathematics, and too small a proportion of the natural and physical sciences ; or could the former be curtailed and the latter increased with advantage ?

"2*d*. Does the course of study seem to you to embrace too large a proportion of purely theoretical instruction, and too small a proportion of practical instruction ?

"3*d*. Considering the qualifications demanded of American Civil and Mechanical Engineers, is there any study omitted in the course which ought to be introduced ; it being premised that such an addition involves a corresponding reduction in some other study already prescribed ?

"4*th*. Do you think it would be feasible to impart elementary instruction in practical and mechanical engineering, by means of lectures, given by experts, in machine shops and on the ground where construction is going on ; the object being, not only to better fit men for practice, but to illustrate and vitalize theoretical study ; or would such instruction be too superficial to warrant the necessary expenditure of time ?"

(Signed by the Committee.)

It will be sufficient here, to state generally that the hopes and expectations of the committee were not fully realized in the results of their correspondence ; and their disappointment may be readily explained. The questions propounded were difficult enough to solve, with all the facilities of a full knowledge of the structure and organization of the Institute, derivable from proximity to it, and from frequent intercourse with the faculty. How much more so, then, to those who possessed no such facilities ? The committee were not slow in discovering that they were merely shifting their own responsibilities upon the shoulders of those whose means of carrying them were inferior to their own. Still, the keen perception of many of these gentlemen, and their practical experience in the same difficulties, enabled them to divine, approximately, the status of the questions, and to give such conclusions as their valuable experience had formed in their own minds. Hence, although the results of the correspondence fell below expectations, it was by no means fruitless. As was to be expected, there was a wide diversity of opinion ; but the general current, with respect to the importance of mathematical training, tended strongly in one direction, viz. : *that so far as it related to civil engineering, it should not be curtailed*. Upon this conclusion the committee have considerable to say elsewhere, and merely remark here that they accept entirely this view, so far as applicable to the civil engineering course, as being quite correct. Possibly the Board of Trustees will attach all the more weight to this conclusion, when it is stated that the committee have been converted to it from opinions inclining to the opposite direction. And this conclusion is not due merely to the testimony and authority of their correspondents, but is also strongly sustained by careful, independent investigation, and comparison of the relations of education to practice, and of the relations of this Institute to others throughout Europe and America.

But the relative proportion of mathematical training, the committee soon discovered, was by no means the whole, nor even the most considerable part of the subject matter before them. The decision arrived at, with respect to this point, still leaves untouched the proportions of other

studies, the practical or technical, and also those having reference to the general culture of the student. The importance of these is certainly not inferior to that of mathematics. The committee assume that the objects for which the Institute exists are, not merely to provide young men with a knowledge of mathematics, and to familiarize them with with learned text-books, but to qualify them for the practical application of science to the useful arts. If this assumption is not correct, it ought to be. If it is not correct, this has no right to be called a polytechnic, or even a technic school, and if it is not a technical school, it should be made so at once. But it *does* profess to give technical instruction, and *does* contemplate the qualification of young engineers; and the ground your committee take is, that its substance should in every possible way be fully equal to its claims. We must not be diverted from a just appreciation of the matter by the objection, which has been often raised, and will be raised again and again, that schools are designed merely to teach principles, while practice is learned only in the workshop and in the field. It is first to be settled what is principle and what is practice; where is the boundry line that separates them; and whether, after all, there is any boundary between them. This objection your committee have examined thoroughly, with caution and candor, and are prepared to say that there is nothing in it which needs to interfere with the execution of the duty before them, which is to establish the technical part of the curriculum on a basis equivalent to the mathematical part, and commensurate with its high importance. The drift of opinion expressed in the correspondence, is as decidedly in favor of strengthening the practical courses, as it is against weakening the mathematical courses—a view in which we equally concur, for reasons which we hope to make conspicuously evident.

At this juncture it is necessary to call the attention of the Trustees to the organization of the Institute, its system of instruction, and the subdivisions of its courses. By reference to the catalogue it will be seen that the courses are four in number, looking respectively to the education of Civil Engineers, Mechanical Engineers, Mining Engineers, and students Natural Science. Of these four, only have a natural existence, viz.: the courses in Civil and Mining Engineering.* The course in Mechanical Engineering is not given, and that in Natural Science graduated but one student at the close of the last year. The first two years' study is common to all the sections, while during the second two years, more or less divergence and separation takes place. But the separation is for the most part imaginary, since the sections not only have many studies in common, but they recite together in all studies in which the degrees of advance are equal. This system and its advantages are so obvious as to need

*We present here an abstract of the curriculum:—Course in CIVIL ENGINEERING, four years—Division D.—*Mathematics*: Algebra, Legendre's Geometry; *Descriptive Geometry; Stereotomy; English Language:* Composition and Rhetoric; *French Language; Geodesy:* Chain Surveying; *Mathematics:* Geometry, Analytical Trigonometry; *Descriptive Geometry; Physics:* Natural Philosophy; *English Language:* Composition and Rhetoric; *French Language; Geodesy:* Chain Surveying, Compass Surveying.

Division C.—*Mathematics:* Higher Algebra; *Descriptive Geometry:* General Orthographic Projections; *Chemistry:* Inorganic Chemistry; *Physics:* Heat; *English Language:* Composition; *French Language:* English Translations; *Geodesy:* Compass Surveying, Plane Table Surveying; *Topographical Drawing:* Elementary Drawing; *Mathematics:* Analytical Geometry; *Descriptive Geometry:* General Orthographic Projections; *Natural History:* Botany; *English Language:* English Composition; *French Language:* English Translations, French Composition; *Geodesy:* Adjustment and Use of Field Instruments; *Topographical Drawing:* Maps of Farm Surveys.

Division B.—*Mathematics:* Differential Calculus; Integral Calculus, Calculus of Variations; *Stereotomy:* Shades and Shadows, Cinematics; *Physics:* Electricity, Magnetism; *Geodesy:* Practical Chemistry, Blowpipe Analysis; *Geodesy:* Levelling, Topographical Surveying, Hydrographical Surveying; *Topographical Drawing:* Profiles, Maps of Topographical Surveys; *Rational Mechanics:* Mechanics of Solids, Mechanics of Fluids; *Stereotomy:* Linear Perspective, Plates, Structures; *Physics:* Acoustics, Optics; *Astronomy:* Descriptive and Spherical Astronomy; *Natural History:* Geology; *Topographical Drawing:* Colored Topography.

Division A.—*Astronomy:* Practical Astronomy; *Physical Mechanics:* Mechanics of Solids, Mechanics of Fluids; *Machines:* General Theory of Machines; *Stereotomy:* Stone Cutting; *Geodesy:* Line Surveying; *Natural History:* Physical Geography; *Machines:* Theory of Prime Movers; *Constructions:* Stability of Structures, Construction of Engineering and Architectural Works. Designs for, and reviews of, Special Works; *Geodesy:* Line Surveying, Staking out for Construction; *Road Engineering:* Common Roads, Railroads, Canals, Tunnels; *Chemistry:* Technical Chemistry; *Geology:* Practical Geology, Technical Geology; *Topographical Drawing:* Plans, Profiles, and Sections of Railroad Surveys.

Course in MINING ENGINEERING, four years—Division D.—The course identical with that in Civil Engineering.

Division C.—The course identical with that in Civil Engineering.

Division B.—*Mathematics:* Differential Calculus, Integral Calculus; *Stereotomy:* Cinematics; *Physics:* Electricity; *Chemistry:* Qualitative Analysis, Stoichiometry; *Natural History:* Mineralogy, Lithology; *Geodesy:* Practical Trigonometry, Levelling, Topographical Surveying; *Topographical Drawing:* Maps of Topographical Surveys; *Rational Mechanics:* Mechanics of Solids, Mechanics of Fluids; *Physics:* Acoustics and Optics; *Chemistry:* Qualitative Analysis; *tory:* Mineralogy, Geology, Zoology, Palæontol *graphical Drawing:* Colored Topography.

Division A.—*Physical Mechanics:* Mechanics of Solids, Mechanics of Fluids; *Machines:* General Theory of Machines; *Chemistry:* Qualitative Analysis, Quantitative Analysis; *Metallurgy:* General Metallurgy, Special Metallurgy; *Natural History:* Mineralogy, Geology; *Chemistry:* Quantitative Analysis; *Geodesy:* Mine Surveying; *Practical Mining:* Sinking and Driving, Exploitation, Ventilating and Lighting, Drainage, Dressing of Ores, General Management, Designs for, and Reviews of, Special Metallurgical and Mining Operations.

no discussion. It is the plan adopted at all technical schools, and no other is worth mentioning.

But to convey a clear idea of the relation of the Rensselaer Institute to the highest and best methods of technical instruction hitherto attained in this, or other countries, it appears proper to give an outline of a fair sample of the European technical school, located in a country where this form of education has been growing and perfecting for about half a century. For this purpose the school of Carlsruhe, in Baden, is selected, not because it is superior to others, but rather because it is an average specimen.

It is necessary to premise that the whole range and scope of education, from the highest to the lowest, is, in all the German States, supervised and sustained by the governments. There is no question there whether Government ought to undertake the higher education of citizens. It assumes it as a duty and a privilege; and though it requires that those who receive its benefits should pay part of its expense, it sees to it that nothing is lacking, which is in its power to provide, to the widest development, most thorough efficiency, and ample equipment of all its schools, from the highest to the lowest. Hence it has come to pass, that not only is every grade of public school the best possible in itself, but it is part of a great system. The schools are graded in such a manner, that each lower grade is preparatory to a higher, and each higher grade begins where the next lower left off. Up to a certain period and stage of development, the course of education in the public schools is uniform for all pupils. Beyond it, there is a divarication into two parts, one of which is chiefly literary, and has its culmination in the university; the other, scientific, culminating in the polytechnic school. These embranchments are coördinate, equal and complementary, each representing an education upon a basis, to a certain extext, peculiar and distinct. The preparatory school for the university is the *gymnasium*, which corresponds pretty nearly to our American college—the university itself being a type of organized education which cannot be adequately represented by anything in this country. The preparatory school for the polytechnic is the *real-school*, which has not the remotest trace of a representative among us.* In it are taught the whole range of the lower mathematics, including plane geometry, algebra, trigonometry, and conic sections; also the elements of the physical and natural sciences, with the languages, including Latin, French, and generally English, and those moral, ethical and æsthetic branches which are deemed absolutely indispensable to what is understood to be a liberal and thorough education. When the pupil of the real-school enters the polytechnic, he is reasonably proficient in every kind of general study, excepting the higher mathematics. Henceforth his efforts are occupied with higher and technical studies alone. He has mastered the elements of nearly everything which can be systematically taught, and all that remains is to give special, and in some cases, extended developments to certain branches, selected with reference to the trade or profession he expects to pursue. Among the many excellencies of this admirable, it will be seen that the polytechnic schools are not hampered with the early and preparatory education of the scholar, but have solely to deal with his professional training, a feature the importance of which cannot be exaggerated, and which relieves the schools of one of the most perplexing and annoying difficulties which your committee have been compelled to face. Returning to a synopsis of the Carlsruhe school.

This school contains the following departments:

1. The mathematical school, which is designed to comprise, in a separate course, nearly all the mathematical instruction which will be required, and thus leave the other and technical course free and unhampered. It is preparatory for three of the strictly technical courses, and the graduate in this department is still not entitled to a professionl degree. The time of study in this department is two years.

2. The school of civil engineering. In this the studies are almost purely technical and practical, with some branches of higher cultural studies. The candidate must be graduated at the mathematical school, or show that he possesses an

* This is a mistake. The Brooklyn Polytechnic Institute includes in the curriculum of its "liberal course" all of the courses of study belonging to the real-school of Carlsruhe.—[Ed.]

equivalent amount of knowledge. The course in engineering proper is two and a half years.

3. The school of architecture. The candidate must have graduated at the mathematical school, and his technical course lasts four years in addition. This is reckoned the most difficult and most learned of all the scientific professions, and perhaps a six years' course of preparatory study in a polytechnic school may in some degree account for the precision, economy, and taste of the German architects.

4. Schools for foresters. The forests of Germany and France are under the protection of the Government, and are cultivated scientifically, and in such a manner as to yield a constant and important revenue. The officers in charge of them are usually Government officers, who are required to be men of education. Hence, nearly every polytechnic school in those countries has its department of forestry, which is taught like any other useful art. The candidate enters the school, either from the gymnasium, or the real-school, and is not required to pass through the school of mathematics. The course is three years.

5. The chemical school. This department conducts the education of certain classes of manufacturers, of chemists and druggists, and is, besides, a preparatory course for the mining schools and for metallurgy,—branches which are taught separately in great establishments like the Freyburg school of mines and the Leoben metallurgical school. The preparation required varies with the destination of the student, who must be at least seventeen years of age. The time of study is also variable.

6. Mechanical engineering. The preparation must be in the mathematical school, and the technical course is two years.

7. Commercial school. The student enters from the real-school and studies one year.

8. School for the education of employees of the post-office. The student enters from the real-school and studies two years. The course includes political arithmetic, geography, political economy, popular jurisprudence, commercial law, the mechanics of transportation, modern history, French and German literature, and the English language. Thank God there is one country in the world, where civil employees of the Government are required to know something.

9. Agricultural school. The student enters from the real-school, and studies two and a half years.

Here, then, are nine departments, or if you prefer, eight technical departments and one preparatory. Some polytechnic schools comprise more. But mining and metallurgy, even then, are taught in separate schools, located—the one near mines, the other near extensive furnace districts. All this may serve to convey some idea of the wonderful refinement of the science of education in Germany, and the exquisite adaptation of its means to ends. But how painful and humiliating the contrast, when we turn to our own country, where the field of the engineer or artisan is the widest, and where his education can be made to yield the largest results, in economy of production and rapidity of development, and yet where the advantages of education are often doubted, or even ignored.

Reverting to our own school, its disadvantages will be seen to be many. In the first place, through want of the counterpart of the real-school, it is difficult to prepare candidates for its courses of instruction, and their qualifications are therefore very low. They are not prepared with any of those elementary and fundamental sciences, which are indispensable to progress in their technical studies. They are uncultivated in everything which constitutes culture, and in short, are utterly unprepared to begin the courses they expect to pursue. There seems to be no complete remedy for this at present, and in the existing state of education we must temporize with the difficulty as best we can. There seems to be no help for it, and the Institute must continue, as heretofore, to devote the earlier year or two of its instruction to preparing its students to begin the "polytechnicum." Just now this preparation takes two years, and only two more remain to effect what European institutions require from four to six to accomplish. Although this may be amended somewhat, yet the larger part of the difficulty will remain, and must be tolerated. It is a poor consolation that no other institution in the country can do any better.

You will perceive then, gentlemen, the nature of our difficulty. You do not need to be told, in addition to this, that the Institute is poor,—almost poverty-stricken ; that the State takes no interest in us and lends us no help ; that there is no organized system of education in which our school may play a definite, adapted, cöordinated part ;—all of which are difficulties to which must be superadded the difficulty arising from want of models upon which we may base our organization. Our course in this must be original, and in many respects unparalleled. We have peculiar difficulties to contend with, and we must adopt peculiar methods of conquering them, or else let them alone. We must frame a course of instruction which will cover more ground, cover a wider range between the proficiency of admission and that of graduation, and carry it out with means far inferior to those of European schools, and worst of all, do it in less time. After all, there is something amusingly national in all this. It is the way we build our railroads and bridges, create corporations, run through financial schemes, create States and Territories, build cities, bolt our dinners, and pack our pork. But let us hope the time will at last come, when, however swiftly we may organize, and however superficially or temporarily we may construct, we shall at least educate our children with deliberation, and on a sure and stable basis. Just now we are driven to expedients, and must make the best of them. It will be a miracle, though, with all this stretching and spreading out of our slender resources, if they do not lie very thin somewhere.

The foregoing comparison with the foreign technical schools serves to bring prominently into view the importance of the first recommendations which your committee desire to make, viz.: a material elevation of the standard of scholarship for admission. This, so far as it goes, will help very considerably to clear away one great difficulty, and give more time both to faculty and students. Let us remember that every day, and every text-book we can crowd back into the preparatory schools, is clear gain to us in every way; indeed the advantages are too conspicuous to need mention. The only question which can arise as to the propriety of such action is, how much can we thus crowd back, without crowding something essential out of existence altogether. We must not put into this list anything which is not usually taught in those schools where students are generally prepared for admission to college, or to this school ; otherwise we should leave a gap in the course of study, which could not be filled, except by extraordinary means. Hence we are estopped at once from raising the standard to anything like the degree to which it is eminently desirable to raise it. Still, there is room for some improvement, and possibly, by a little exertion, we may make some more.

The places where boys are prepared for college are usually high schools, and those private or endowed schools, which like the Williston, at Northampton, and the school at Andover, Mass., are established almost exclusively for this purpose. Some of these graduate scholars qualified to enter this Institution at the second year, and some even confer additional qualifications. By a little addition to this instruction, the Troy High School could enable its graduates to do the same, with a few inconsiderable exceptions. The High School contemplates the due preparation of students to enter college ; why may it not extend its preparations to admission to a higher technical school ? Indeed, this proposition merely contemplates a little hastening of a step which is sure to be taken at no very distant day in the future. The general and radical change of conviction among educators and educated men respecting the relative importance of literary and scientific cultures, educations, and professions, is even now building up everywhere in the land technical and industrial schools, and their demands for due and peculiar preparation must be met, and met by means similar to those employed to satisfy the older colleges. Nothing can be more certain than this, and why should not Troy have the honor of first recognizing the coming change, and of being the first to acknowledge and prepare for it ? Certainly the city of Troy could not do less than to respond to a request of this nature, and even might be willing to take some pains and submit to a little expense, if necessary, to render us such welcome aid.

It is recommended, then, that application be made to the Board of Education to receive candidates for admission to the

Institution, whether resident or non-resident, upon such terms as may seem proper and equitable, and permit them to receive the benefits of the High School, which may prepare them to meet the advanced requirements to be proposed by the committee; it being understood, however, that no material change be asked for in the present course of instruction at the High School. Indeed, no great change will be necessary. It is believed that by requiring High School pupils, or such of them as may contemplate entering the Institute, to complete plane geometry, elementary plane problems in descriptive geometry, lower algebra, natural philosophy, and some text-book on rhetoric, the High School course would not be seriously incommoded, and the Institute would thus be able to gain time equivalent to two-thirds or three-fourths of a year. Most of these branches are already taught, either wholly or in part, and every one of them is, in its entire extent, pre-eminently a High School study, and ought to be taught there and nowhere else. It would not be practicable, just now, to state precisely how far this arrangement could be carried by the High School, but it is suggested that the proposition be made to the Board of Education, and if accepted in a general way, the exact details could be readily arranged.

Having cleared away some of the rubbish in our path, we may now see our way more clearly to other changes. Reverting to our discussion of the courses, we may now call attention to the fact, that the civil and mining sections differ markedly in their respective degrees of excellence. It is the civil engineering course which has hitherto sustained the good repute of the Institute, and to the maintenance of its high standard of excellence, the greater share of the resources and working force of the Faculty are devoted. The mining section is most promising, and well patronized,—no less than 40 students out of the 120 of last year either receiving it or contemplating it. It was very recently organized, while the civil engineering school began with the Institute. So far as the mining section is distinct, it is sustained, just now, almost entirely by the labor of one professor. Without wishing to be invidious, and while expressing great gratification at the industry and efficiency of the faculty in general, the committee desire to commend, in high terms, the zeal, energy and enterprise displayed by Prof. Maynard under peculiarly trying circumstances. But in spite of the best that could be done, the mining course is inferior to what it ought to be, and even to what it might be. The very considerations which have led the committee to approve, for the most part, the civil engineering course, have led them to disapprove the present mining course. The objections lie chiefly in the distribution of studies. Stated in general terms, the course is too mathematical, and too little technical. The educational wants and necessities of the mining engineer are not only different from those of the civil engineer, but differ in America from corresponding wants in Europe. As the wants of the miner have everything to do with the subject, let us examine the case a little.

The difference between European and American mining is immense. Every European country has been rummaged, scoured, screened, and washed for minerals, for thousands of years. Coal lies thousands of feet below the soil; all the rich seams of metallic ores, excepting iron, were exhausted centuries ago by the wasteful, barbarous smelting of old and mediæval nations, and the poorer lodes, which would yield to more refined processes a scanty margin of profit, have been chased down into the bowels of the earth, beneath the sea, or into the cores of the mountains, where the pump can do no more, or where the volcanic heat of the earth foretells the final barrier. Thus, every century has increased, and will continue to increase, difficulties which have now become enormous, and full of imminent peril. To conquer them requires the highest resources of the engineer, the utmost intelligence of the geologist, and the best skill of the mechanic. How different in America. Our coal lies upon the surface, and the getting it is scarcely more than quarrying it. It lies in seams quadruple the thickness of those in England, cropping out on the mountain sides, where we *go up* to get it, instead of down. Our iron lies in the form of rich magnetites, and 98 per cent. hematites, in the bluffs overhanging the rivers and lakes which will float it to the blast furnace, and single seams will yield, by sur-

face, or gallery, or pit mining, hundreds of millions of tons. Our copper is dug native, within reach of the daylight; our galena has just earth enough over it to keep it from the malign influences of the air, and our silver is still extracted without the aid of prop or column. Gold, it is true, is an exception, and is now chiefly mined in shafts and subterranean galleries. You will appreciate, then, that the functions of our mining engineer are less difficult, and of a widely different nature from those of the European. His methods are less uniform, and are governed entirely by circumstances, which vary with almost every metalliferous deposit. Hence, his engineering requirements are of a lower order, less costly, with less of construction and more of mechanical appliances, less of skill and more of rude labor, and the readiest adaptation.

Another marked distinction is this. The American miner must also be a good metallurgist. In Europe it is believed that the miner has enough to do and to think of, in getting the ore, without troubling himself about what is to become of it. This accords well with the tendency to extreme division of labor prevalent in Europe. It is seldom that single establishments, like Krupp's or Schneider's, comprise consecutive processes, from the ore to the finished product. But even these somewhat exceptional establishments are so colossal in their extent, that they, too, must refine the division of labor, and establish a sort of industrial world and economy within themselves, so that the principle still holds good. In the great iron industry, the tendency has been and still is towards great variety in the products of the blast furnace, and the adaptation of special brands of pig to special purposes. Take a steam engine. Forty years ago, it might all have been built from the product of a single blast furnace. Now, it is more likely to require iron from a dozen. One brand is suitable for bed plate, another for frame, a third for cylinder and steam chest, a fourth for conversion into wrought metal for piston and connecting rods, and still other varieties for the many other kinds of stress. In short, the gist of the whole matter is, a mining engineer must know both how to get ore, and what it is good for; must be both an engineer and a metallurgist. If the vein changes its character, he must know how the change will affect the furnace and the resulting products. As a consequence, the studies he should pursue must not be merely those relating to engineering, but they must be metallurgical also. His engineering requirements will seldom be such as to demand much of the higher mathematics—with a solitary exception, to be pointed out hereafter. But he must be an expert geologist and mineralogist, and must have a substantial working knowledge of physical science, and an extensive knowledge of chemistry and assaying. His attainments may be divided into two classes:

1. Exploitation, or the practical working of mines.

2. Metallurgy, or the reduction of minerals.

The first calls for a thorough knowledge of structural geology and mineralogy, of pumping and hoisting machinery, of the steam-engine, of underground surveying, and of the mechanical appliances and methods for driving shafts, tunnels and drifts.

Metallurgy requires a knowledge of chemical analysis, assaying, mineralogy, the construction and economy of engines, furnaces, fuel, materials, and of the construction of buildings; to which may be emphatically added a knowledge of the laws and theory of heat, both as a motive force and as a reagent.

The civil engineer and architect may frequently be called upon, especially in bridge building, roof construction, arch work, water supply, etc., to apply the analytical mechanics to the problems before him, and the mechanical engineer may be similarly called upon in his profession. But it appears doubtful whether in this country, a knowledge of the higher rational and applied mechanics will ever be particularly useful to the mining engineer, in the direct line of his profession. On the other hand, his knowledge of those branches of physical and natural science, which bear directly upon it, should be as decidedly developed as the knowledge of mechanics in civil engineering. And herein seems to lie the radical difference between the two professions. The one is the application, chiefly, of mechanical science, the other of physical and natural science to the useful arts; and the stress of teaching should, so far as practicable, be regulated accordingly.

It appears to the committee that, under the present arrangement, the degree of mathematical training for mining engineers is excessive, and the training in natural and physical science, and in the technology of their profession, is deficient. It is true that the curriculum announces a reduction of the mathematics, and special extensions of the sciences and technical studies; but these modifications seem to be very inconsiderable, and very inadequate. The mining student is now required to study most of the text-books of the civil engineer, while his technical course is crowded into the odds and ends of time which are left after this exhausting course is satisfied. The changes which we recommend will be specified more fully hereafter; we confine ourselves here to saying that we recommend a much more thorough technical course, and a less stringent mathematical course, for the mining engineers.

In following out the relations of the courses of study to each other, and comparing the condition and prospects of the Institute with those of other Institutions, which are now entering the great field of technical education, your committee have had occasion to reflect frequently upon the desirableness of establishing the course of *mechanical engineering* upon a basis similar to that of civil engineering. The desirableness, indeed, no one has ever questioned, and the only obstacle is in the ways and means. So desirable does this important expansion seem, that they have been led to scrutinize very closely all the bearings of the proposition, particularly the financial bearings; the result of the investigation being a belief that, within the coming year, it will be well worth the while of the Board of Trustees to make some unusual effort to secure this object. We are prepared to go even further than this, and state it as our settled conviction, that unless such an effort be made, and *successfully* made, the Institute will be compelled to submit to a serious loss of patronage and prestige, by the superior claims of other institutions, which are making most strenuous efforts to preoccupy this field. While other institutions are making rapid progress, the Rensselaer cannot afford to stand still. Hitherto it has sustained both its reputation and its patronage, by keeping itself courageously at the head of all American technical schools,—or rather by being almost the only technical school in the land, and assuredly the only one maintaining a standard of scholarship at all comparable to those of European schools. Whenever it permits, either voluntarily or by compulsion, any other institution to wrest from it that supremacy, it must begin to decline. Your committee therefore believe that the establishment of this course is, in a certain sense, compulsory, as will appear from the following considerations. Hitherto the Institute has never suffered from want of patronage, because it was without any formidable competitor. Throughout the United States, no school has ever taught civil engineering with equal efficiency, and no school has ever had an equal reputation in that specialty. But in the coming year, both Yale and Harvard will issue programmes of courses in civil, mechanical and mining engineering, which will, in most respects, equal, and in some few surpass, the utmost that the Rensselaer can hope to do. In addition to programmes, they will offer an array of museums, models, drawings, and all the paraphernalia of instruction, by the side of which our own will seem contemptible, and a corps of instructors double or treble ours, and of world-wide reputation. These institutions would long since have been in the field with the same heavy armament, had they not been compelled to fight the battle of science against classics, of things against words, of the new against the old. Thanks to the resistless progress of ideas, the new education has fairly conquered a recognition, full and explicit, of the fact, that science and the useful arts constitute a culture, an endowment and qualification most certainly not inferior to the highest boast of the old regime; and the same power of inherent worth and native strength will, in a few years, utterly discrown its old adversary and usurp its supremacy. But the recognition of equality is perhaps sufficient for present purposes, and is a victory whose advantages are as great as can be immediately utilized.

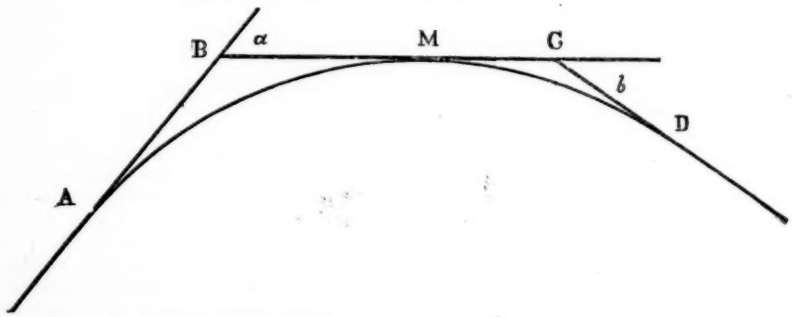
All this may be said to be achieved at Harvard and Yale within a year, and the leaders of scientific thought, who generalled the campaign, are already on the move to push their victory to its last results, which must necessarily be the establishment of first-class technical

schools. They have already been endowed, but have well-grounded hopes of still more munificent donations. The courses marked out are comprehensive, flexible, and thorough, as befit such famous institutions.

While prosecuting their inquiries regarding a school of mechanical engineering, your committee have become convinced that the whole subject has been, heretofore, for the want of thorough investigation, somewhat misapprehended by teachers as well as by the public. The scope and possibilities, and hence the usefulness of such a school, do not seem to have been fully appreciated, and the impracticabilities in the way of its success, such as costly apparatus, an unduly protracted course, and the difficulties of teaching applied mechanics by means of books and lectures, appear to have been unduly magnified. Your committee therefore plead, not only the importance of the subject, but its novelty and the unsettled state of opinion regarding it, as a reason for its somewhat extended consideration in this report, in the hope, not of finally settling the principles and conduct of such a course of instruction, but of removing some of the difficulties in the way of its successful establishment.

[TO BE CONTINUED.]

A NOTE ON RAILWAY CURVES.



The limit to the length of radius of a railway curve is frequently fixed by the proximity of the next curve; this is specially the case in rough sections.

The maximum value admissible in such cases is that of a radius common to both curves, or rather of a curve drawn to three tangents.

The radius and tangent points are readily found, as follows:

Let r = the radius.
" d = A B = B M.
" l = B C the length of the middle tangent.
then $l - d$ = M C = C D.

Now $r = \frac{d}{\text{tang } \frac{1}{2} a}$ for the arc A M, and $r = \frac{l-d}{\text{tang } \frac{1}{2} b}$ for the arc M D.

But these two values are to be equal, hence $\frac{d}{\text{tang } \frac{1}{2} a} = \frac{l-d}{\text{tang } \frac{1}{2} b}$; from which we get $d = \frac{l \text{ tang } \frac{1}{2} a}{\text{tang } \frac{1}{2} a + \text{tang } \frac{1}{2} b}$, which determines the points A and M, and r which is equal to $\frac{d}{\text{tang } \frac{1}{2} a} = \frac{l}{\text{tang } \frac{1}{2} a + \text{tang } \frac{1}{2} b}$.

The method applies also when the curve reverses at the middle tangent point.

When it is desirable to have a certain length of tangent between the end of the first arc and the beginning of the second, this length must be subtracted from the middle tangent, and the remainder tal en as the value of l.

THE "filling in" to the chamber of the caisson of the East River Bridge will commence shortly. The excavation is about completed.

THE BOUNDARIES OF SCIENTIFIC KNOWLEDGE.

From "The Mechanics' Magazine."

The lecture on "The Scientific Use of the Imagination," delivered by Professor Tyndall in Liverpool before the British Association, harps upon a subject which also claimed the attention of Professor Huxley, Mr. J. Clerk Maxwell, F.R.S., and Professor Roscoe, F.R.S., in their respective presidential addresses. All of them expressed the desire to see more of the constitution of common matter than the microscope is competent to reveal. All the leading philosophers of the day agree, perhaps without an exception, that light consists of wave motion of the interstellar ether, the evidence being now irresistible, but they are not so well agreed that common matter consists of vibrating rigid atoms. Professor Tyndall brought one splendid idea to bear with great force on the latter subject. He said, in effect, that when waves of sound strike the ear, if we trace those waves to their origin, we always come to a vibrating string, or tongue, or substance, originating the impulses in the air. When mechanical waves of light strike the eye, if we trace out those waves to their origin, how can we expect to find anything but substantial vibrating particles producing the wave motion? Again, it is absolutely certain that the components of common matter, whatever they may be, are in constant motion.

Mr. Clerk Maxwell, Mr. J. Johnstone Stoney, and other philosophers, have spoken much at the British Association of the "vortex atom" speculation, originated by Sir William Thomson; but as none of the speakers at Liverpool explained to the listeners the nature of the idea, perhaps a few particulars given here will be of interest. Helmholtz demonstrated by mathematics that if a "perfect" fluid—that is to say, a fluid destitute of viscosity or fluid friction—were once thrown into a state of *wirbel bewegung*, or vortex motion, it must of necessity preserve that motion to all eternity. Sir William Thomson, taking up this idea, suggested that atoms might be vortex rings of that nature. He and Professor Tait then devised a very remarkable experiment. As they could not get command of a perfect fluid, they were obliged to choose an imperfect one—common air—and then they found means to throw it into vortex rings. They took a large square box and cut a hole as big as a cheese plate in one end; they then cut the opposite end of the box away entirely, and tied a cloth on to its place. Then every time they banged the cloth with the hand at one end of the box, a vortex ring of air was driven out at the other. How were these rings to be made visible to the eye? They filled the box with white smoke by allowing hydrochloric acid gas to enter the box through one little hole in the side, and ammoniacal gas in excess to enter through another; when these two gasses mixed they formed a dense white smoke, so that every time the cloth was struck, out flew a vortex ring of air holding white smoke in suspension. The white rings floated about the room and lasted for some little time, but, air not being a perfect fluid, they finally melted away. It was a curious sight to see two of these rings come into collision in the room, for then they rebounded from each other like india-rubber belts.

This article is headed "The Boundaries of Scientific Knowledge;" and there is another field of mystery which enters much into the consideration of the philosophical mind, but which was not brought under the notice of any section of the British Association. That subject is, the numerous instances in which solid objects rise or float in the air by some force having no weight of itself, yet competent to overcome the attraction of gravitation. Professor Tyndall recently exhibited a case of this kind at the Royal Institution, when he showed two little fishes cut out of gold leaf quivering in the air near the knob of a charged Leyden jar. What held those fishes there? "Electricity," is the ready reply. Yes; but electricity has no weight; so here is a clear case of "something" without weight supporting in the air metallic gold, one of the heaviest of the metals. The said "something" was also invisible by daylight, though had the light been shut out a beautiful brush-like electrical discharge would have been seen emanating from the pointed tails of each of the two fishes. Magnetism likewise, as everybody knows, will cause a

piece of iron to rise in the air in opposition to the attraction of the earth, and this phenomenon is at the present time perfectly inexplicable by the man of science.

A very interesting experiment connected with this subject was recently performed at the telegraphic soirée given at the house of Mr. John Pender, on the occasion of the opening of direct electrical communication with India; the Prince of Wales, it may be remembered, was present on the occasion. As the experiment is a new one, and the details have not as yet, we think, been published in any journal, it may be of interest to many men of science if we publish them here. Lord Lindsay had at the soirée an enormously powerful electro-magnet, with adjuncts to facilitate experiments in diamagnetism. The poles of the magnet were square and two inches across, and when a half-crown was allowed to fall through the air between these poles it took four seconds to fall through the two inches of space containing nothing possessing weight except common air. This is a common enough experiment, but Mr. C. F. Varley, C. E., the electrician, devised a novel experiment to show that the magnetic rays do not hold up the half-crown, but generate electrical currents to produce the effect. He had some copper wires bent into rings and soldered together; the wire was 1-16th of an inch in diameter, and the ring 1¼in. These rings were seven seconds in falling through the two inches of magnetism, but on breaking the soldered junction, and thus preventing the well-known formation of electrical currents therein, the ring fell through the space very rapidly. Mr. Varley concludes that this experiment proves "that a current of electricity is as solid and material to a magnetic field as is a plate of iron to a bar of copper." The general subject of the suspension of solid substances in the air, in opposition to the attraction of the earth, and by invisible forces, or perhaps substances having no weight of their own, is worth consideration in one of the sections of the British Association next year.

RAINFALL—ITS VARIATION WITH ELEVATION OF THE GAUGE.

By CHAS. CHAMBERS, F. R. S.

From "The Engineer."

The fact is well-known to meteorologists that the quantities of rain received in gauges placed at different heights above the ground diminish as the elevation of the gauge increases. Several attempts have been made to explain this phenomenon, but none of them are so satisfactory as to discourage the search for other causes that may contribute substantially or mainly to its production. Hence the submission for the consideration of the British Association of this further attempt. One of the principal causes of rain is undoubtedly the transfer, effected by winds, of air charged with moisture in a warm damp district to a colder region, where the vapor it contains is partially condensed. The temperature of the lower as well as of the higher horizontal strata of the air being reduced by this transfer, it may fairly be inferred that condensation of vapor will also occur in the lower as well as in the higher strata. The rain caught by a gauge at any given elevation will therefore be the sum of the condensations in all the strata above it, and thus the lower a gauge is placed the greater will be the quantity of rain received by it. Again, it is known by observation that there is at all times a greater or less difference of electrical tension between the atmosphere and the surface of the ground. If, then, in accordance with the views of Professor Andrews as to the continuity of the liquid and gaseous states of matter, from which it follows that the change of other physical properties must also be continuous, we regard the particles of vapor suspended in the air as electric bodies in relation to the dielectric principal constituents of the atmosphere, they will be polarized by induction from the electricity of the ground. This polarization will give rise to an attraction between every particle and the neighboring particles above and below it; and being stronger in the particles nearer the ground than those more

remote, the tendency of the particles to coalesce—which will increase by their mutual induction as two neighbors approach each other—will be greatest near the ground. Thus it may be—each particle gathering to itself its neighbors successively till their united density exceeds that of the atmosphere generally—that some rain drops are formed, and that in greatest abundance near the ground. If this be the true cause of any substantial part of the phenomenon in question, then, as the variation of intensity of electrical polarization of the particles will vary with height most rapidly near the ground, so the variation in the rainfall near the ground should be more rapid than at a greater elevation; and such is indeed the fact.

Also, if the idea be correct, it will probably serve to explain other phenomena which it was not specially conceived to meet; and so it does. For, first, it requires that the rainfall over even ground, when the electrical tension is relatively weak, should be less than over similarly situated forest land, where at the tops of the trees, ends of branches, and edges of leaves, the tension is high; and this is in accordance with observation. And, secondly, the tension being relatively high at the tops of the elevations of a mountainous district, the rainfall should be greater there than in the neighboring plains; this again is borne out by observation. Further, at the commencement of a passing thunderstorm, a sudden heavy shower of rain will often fall for a few moments, and then suddenly cease. May not this arise from the approach, by the agency of opposite wind currents, of detached masses of oppositely charged clouds—the process just described of formation of raindrops going on rapidly in each mass as the two come near each other, and stopping when by a flash of lightning between them the two masses are brought into the same electrical condition. An experimental test of this idea would be to repeat Dalton's measures of the pressure of vapor in the vacuum space of a mercurial barometer tube, filling that space with air and a little water; and compare the values found when the mercury was charged with electricity, and when not so charged. If in the former case a less pressure was found, we might conclude that the particles of vapor are really susceptible of electric induction; and the amount of difference existing would enable us to estimate whether the attraction of the particles upon each other were strong enough to cause the formation of raindrops hypothetically attributed to them above.

SUBMARINE BLASTING.

A paper read before the Am. Society of Civil Engineers by F. COLLINGWOOD, C. E. gives the following:—

In excavating for the foundation of the Brooklyn pier of the East River Bridge, the bottom was found to have, running about through the centre of the excavation, a ridge of exceedingly hard material, being composed of boulders of all sizes imbedded in compact clay.

As the dredges would scarcely scratch the botttom after this was reached, the following method of loosening it was adopted:

A solid iron pile, 18 ft. long and 5 in. diameter, shod with steel, with a ring at the upper end for hoisting, was driven by an ordinary pile-driver down to the desired depth. On withdrawing it, it was found that a perfect hole was left, into which a tin canister containing 13 lbs. of powder was easily inserted. The effect of the charge was to leave a crater reaching at the centre below the desired bottom. The success of the experiments was so decided that another pile of 5 in. diameter and 22 ft. long, and one 6 in. diameter and 22 ft. long, were procured. By the aid of these, with 2 pile-drivers and crews, and a diver and assistants, from 20 to 40 blasts per day were fired at a depth of 18 ft. below mean high tide.

The dredge was able (after the bottom had been gone over in this way) to excavate from 50 to 120 yards per day.

The material was from 2 ft. to 8 ft. deep.

Time of driving about 5 minutes.

Cost probably about $3 to $4 per cubic yard.

When the pile fastened between two boulders it had to be loosened by blasting round it.

The economy of the operation as compared with the usual method of drilling is very decided.

TIMBER AND CONSTRUCTION.

From "The Builder."

One architectural characteristic of the present day is the substitution of iron for various materials used in construction down to the earlier portion of the nineteenth century. The origin of the change was not of an architectural nature. It was neither the destruction of forests, the loss of skill, the sudden discovery of any new material, or property of a material, or any of those changes to which we are accustomed to attribute the previous modifications in the form of Christian architecture. But the seed and principle of the new style is referable to the fact that, some sixty years after Watt has first learned how to derive motive power from the expansion of water by heat, a colliery laborer succeeded in applying that same power to the propulsion of carriages by land.

With the construction of the Liverpool and Manchester Railway, in 1828 and 1829, an entirely new era was inaugurated. Structural requirements were altered, and the effect of the alteration very soon became evident in monumental form. With an increased facility for the transmission of heavy weights over lines of iron rail, a demand for an improved mode of bridging over rivers, roads, or other openings, sprang up. The supply and the manufacture of iron thus received a stimulus, and the iron trade, in its turn, reacted upon the designs of the architect and of the naval constructor, by giving him a material which was virtually a new one. Men of practical mechanical genius first labored to produce structures of wrought iron of which the expense should be reduced to a minimum. Thus Sir Charles Fox, then a subaltern of Robert Stephenson, designed that simple, inexpensive shed roof, for the Euston square passenger station, which for some time was the normal type of similar structures. The taste and lavish expenditure of Isambard Kingdom Brunel next produced the Great Western Station at Paddington. The need of bridging the Menai Straits led to the construction of the hollow box girder, and the piercing of London with railways induced the execution of those effective, but hideous bridges, the aspect of which so afflicts the man of taste. Soon the displacement of architectural requisites by structural combinations that took no heed of any laws but those of strength, spread from the floor to the roof—from the bridge to the station; and men vied with one another in the erection of the largest, the most unnecessarily costly, and the most hideously unarchitectural forms that the world has yet seen.

The use of iron for railway purposes has crept in, to an extent constantly increasing, in civil buildings. Vast shop and warehouse fronts of iron are filled with plate glass. Permanent exhibition buildings are erected, of that perishable combination of iron, glass, and wood, which may answer, on a small scale, for a conservatory, but which is the most costly style of structure, as far as maintenance goes, of which we have any experience. Connected with the same increased energy in our workshops are the increase in the power of artillery, the improvements in the manufacture of shot, the launching of iron and steel armored vessels, and the construction of shields for fortresses, as to which, at the present moment, the art of defence is somewhat ahead of the art of attack.

Concurrently with this substitution of iron for wood, and for other materials, there has been, with very few exceptions, a wanton waste of the forest resources, not only of our own country, but of the entire world. Man has come to regard his early cradle, the forest, as an enemy, instead of a benefactor. In England the prudent care of our forefathers to watch the growth of our forest trees—to secure a perennial supply of oak for our ships, as well as of yew for our bows, is altogether forgotten. The forest rights of the crown over a district that has been wooded since the time of Julius Cæsar—the forest of Epping—have been so purposely neglected, that it has needed the very unmistakable expression of public feeling to elicit from the Solicitor-General anything more than a joke upon wolves and bears. The 100,000 acres of forest, under the administration of the Woods and Forests, has been so admirably managed, as to arrive at the result of a rental, at the rate of 3s. 6d. (three shillings and six-pence) per acre. The wooden walls of old England are now

so much an affair of the past, that it may be said that we only regard timber as necessary to ornamental landscape, or as a material for lucifer matches.

It is in this country and its dependencies, and in those of our American descendants, that the laws of Nature, as to the clothing of the earth with timber, have been the most persistently broken. But we are far from being alone in our folly. To whatever part of the world we turn we see indications that waste and destruction bring their own vengeance in their train. Of the effects produced upon climate by the denudation of the soil, there is no room for doubt. To a certain extent the influence of human labor in the thinning of forests is beneficial. But the limits between culture and destruction are rarely maintained. In the year 1816 the forest came up close to Philadelphia. The Delaware, a mile wide, was then often frozen in a single night. The edge of the forest has receded to a distance of more than thirty miles. The thermometer is now rarely down to zero ; the river is hardly ever frozen ; nor does snow lie long on the ground. In the forest it lies very long. The increased aridity of Palestine, of Spain, and of the south of France, is well known. In the former case it has been partly caused by the cutting down of the olive, a barbarous incident of warfare, merely forbidden by ancient law. In the last-named country it has been the need of fuel that has led to the denudation of so many districts, and the double evil has ensued : first, that the humidity of the climate has been reduced to a formidable extent ; and, secondly, that when rain does fall, in any unusual proportions, the absence of the great natural absorbing power of forest districts allows the entire product of the rainfall to be discharged at once by the natural drainage, thus causing those floods which have proved so formidable in their ravages within the last few years.

The denudation of the forests of England is by no means a new grief. More than 200 years ago Mr. Evelyn complained of the rapid extirpation, "root and branch, of all those goodly forests and woods which our more prudent ancestors left standing for the ornament and service of their country." On the confiscation of the Church lands, in 1536, immense forests were cut down ; and during the civil war that commenced a century later, many royal forests, as well as private woods, were entirely swept away. In France there yet exist 2,700,000 acres of State forest, earning a gross revenue of £1,740,000 and a net revenue of £1,240,000 per annum. Bavaria contains nearly 2,000,000 acres of forest ; Prussia, upwards of 5,000,000 ; Austria, no less than 13,000,000 acres, realizing an annual export value of £3,000,000 sterling.

In France and in Germany exist schools of forestry in connection with the service of the State, and men of a superior class of intelligence are carefully trained in these establishments for the scientific management of this important part of the national property.

In Bavaria there is a school of forestry at Aschaffenberg on the Maine. The candidates for admission must have passed good examinations in the higher public schools. The time of training extends over five years, half of which time is devoted to acquiring a practical acquaintance with the condition and the care of the forests of the State. The special scientific course comprises lectures on forestry, management of forests, planting, division of forests into blocks, valuation surveys, rotation of classes of timber, and the due rotation between the maximum yield of a forest, and its maintenance in an uninjured condition. Preparation, transport, and sale of forest produce, form another special branch of study. Botany, chemistry, zoology, physiology of plants, climate, and geographical distribution of plants, form the natural science division of the course ; and mathematics, pure and applied, engineering, surveying, and forest legislation complete the *curriculum*. On passing the final examination, the students are qualified for appointments in the Bavarian forest service.

In France a similar college exists at Nancy, where from thirty to forty students are trained for the service of the State. The service is directed by the "Bureau Central de l'Administration générale des Forêts," and 849 *conservateurs* and *inspecteurs*, having under their orders 3,500 *gardes gènèraux*, have charge of the public forests of France.

Forest schools are also established at Hanover, Newstadt, Eberswald, near Berlin, Thurant, in Saxony, Eisenach, and

other places in countries possessing State forests.

The threatened and very proximate exhaustion of the enormous forests and timber-growing jungles under the British rule in India has led to a tardy attention being paid to this important subject by the Indian Government.

From the report of Dr. Brandis, Inspector General of Forests in India, it appears that the normal average of first-class teak trees in a virgin forest is fourteen per acre. A teak forest at Maulmain, in the hands of the Government, extending over 550 square miles, has been found to contain only three full-grown trees in two acres, while damaged trees and stumps abound.

Forests of the Sâl or Saul tree replace those of teak in Central India, to the north of the Nerbudda river. A belt of forest, from five to twenty miles wide, extends for a length of 1,500 miles along the foot of the sub-Himalayan range, and up to an elevation of 3,000 ft. The Saul tree grows socially, and by its dark green foliage excludes the growth of other trees; being unlike the teak in this habit of growth. In Oude and Nepal the jungles contain as many as seventy first-class trees per acre, together with from 200 to 300 of all sizes, springing up from seed. The system of letting these forests by contract in annual leases to the highest bidder, while bringing in a positively insignificant return, has had the effect of stripping all the accessible parts of this large district of full-grown trees. Such is the size attained by this noble tree, which, with a specific gravity less than that of the oak, possesses from one and a half times to twice the strength of that wood, that the Nepal ferry-boats, used to contain from ten to fifteen men, with horses and cattle, are hollowed out of single logs. The tree takes about 100 years to arrive at this size The British Sâl forests are computed to cover more than 3,500 square miles, and a rest of forty or fifty years will be requisite to replace this watse of first-class trees which has been so blindly permitted to go on.

From the state of the Sâl forests it may be concluded what is the condition of the supply of teak, a tree which grows so much more sparely in its natural home. In 1822 the forests which the native princes had studiously preserved were thrown open to the public. Within eight years it was discovered that, owing to indiscriminate cutting, teak timber fit for Government purposes was growing scarce, both in Madras and in Bombay. In 1839 Mr. Williams, the dockyard manager, reported, that within 21 months 40,000 teak-trees, between 12 in. and 6 in. in diameter, had been floated down by the contractors, whose indiscriminate waste was thus destroying the resources of the future. So great had been the destruction, that in 1842 the Government actually purchased 260 sq. miles of forest land, for replanting with young teak, for the use of the dockyards. It was found that the expense of thus preparing a single acre of forest nursery was greater than the value of the timber which could be grown on a sq. mile in 100 years! During the 20 years preceding this futile attempt to repair irreparable waste, the forests of Malabar, Canara, Goojerat, Bombay, Madras, Rajamunduy, Coimbatore, and Cochin, stocked with first-class trees fit to cut, and with an ample supply of young trees in all stages of growth, had been given over to destruction. The contractors took no heed of those who might come after them, and cut everything that came to hand.

During this time the forests of the Rajah of Travancore, under the charge of an English conservator, had yielded a regular revenue, while still containing a full supply of first-class trees. For every 10 trees fit to cut, 2 were left for seed; and for every tree actually felled, 10 were planted.

The teak-growing districts of Burmah extend over more than 7,000 sq. miles of forest. A system of well-devised management has been introduced into this district, in 1858, by the conservator, Dr. Brandis. The forests are divided into 6 divisions, of upwards of 1,000 sq. miles each, containing an estimated number of 100,000 trees in each district. The trees are divided into 5 classes, each individual tree being allowed a period of 24 years in each class, thus making the total life of the tree, from the germination of the seed to the felling of the timber, 120 years. The ordinary average of the forest gave 100 trees of the first, second, and third classes, and 200 of the fourth class, per mile. By cutting, therefore, only 80 of the first class in 24 years the forest is uninjured, and in the course of 120

years its stock of timber is entirely replenished.

The specific gravity of green teak is greater than that of water. The dry timber, on the other hand, will float. It is therefore the practice to mark and girdle the trees 3 years before felling. The tree is killed by the destruction of its bark, and dies *in situ*. When felled it is dragged to the rivers by elephants, and floated down to Rangoon, the Government paying so much a log on its arrival. Under these arrangements the Burmese forests have kept up a good supply of timber without exhaustion, and have insured an annual profit to the Government of £60,000, besides providing for the expenses of their own conservation, amounting to more than £30,000 a year.

No less important than the conservation of our extensive forests, inexhaustible as they may prove under proper management, although readily destructible by the waste which we have been accustomed to allow, or rather to practise, is the introduction to the knowledge of the English builder and manufacturer, of those noble and beautiful species of wood of which we command so great a variety. It is incredible to what an extent this part of the subject has been neglected. At the Paris Exhibition of 1867, timber from no less than 3,769 distinct species of trees was collected from forty-five different countries. Of this large number Europe contributed 395 species. Africa yielded only 252, showing that the resources of that large continent were almost virgin. Asia produced 858 species, Oceania 966, and America no less than 1,298.

Among the most notable of these materials for the builder may be mentioned the Eucalyptus Amygdalina, from Victoria, which attains in the valleys of Daudemony and on the Yarra river the height of 420 ft. Dr. Mueller says that this amazing height is by no means exceptional, and that it is due rather to great rapidity of growth than to extreme age. The "white gum" (Eucalyptus Stuartiana), and the "stringy bark" (Eucalyptus obliqua), are said to exceed 300 ft. in height, and to cover the plains and more barren mountains of Victoria. From the same vicinity come beautiful ornamental woods. The Senecio Bedfordii, a curious striped wood, and the Banksia serrata, marked with a patern like network. Gipps Land produces the Eucalyptus longifolia, said to last in the ground for twenty years, and the Acacia supporosa, an elastic wood resembling hickory, and yielding straight spars from 50 to 100 ft. long.

British Guiana produces the "Greenheart" (Nectandra Rodeii), called by the natives Sipicu, a timber which is remarkable both for its great durability and for its extraordinary strength, which is three times that of oak. Balks of this timber, squaring from 18 to 24 in., may be had from 60 ft. to 70 ft. long without a knot. In the same locality, the mora (Mora excelsa) attains a majestic height of from 100 ft. to 150 ft. It is so tough that it is sure not to splinter when struck by cannon shot. Its strength is more than double that of oak, and it is said to be exempt from dry rot. Of the seven species of timber which form the first class in Lloyd's classification for shipbuilding, oak, which heads the list, seems to be far inferior to the East Indian, the Australian, and the African timber, to which we have referred. The list includes seven species of timber, the ordinary European oak (Quercus robur), the live oak of North America (Quercus virens), African oak (Quercus Africana), teak (Tectona grandis), and sal (Shorea robusta], from East India; mora (Mora excelsa) and greenheart (Nectandra Rodeii) from British Guiana, and iron-back (Eucalyptus, species not named) from Australia.

It is beyond the limits of our space to describe the varied, mottled, striped, and colored woods which offer such admirable materials for the artist, whether for furniture, for doors, skirtings, and wainscotings, or for inlay work. The use of dyed or stained wood for the latter is rendered unnecessary by the bounty of nature. From the pure white of satin wood, and of numerous other species, to the full lustrous black of ebony, we can simulate almost any that form the resources of the vegetable world. French Guiana produces a violet wood of extreme beauty, the "Bois violet" (Copaifera bractata), and the Caryocar glabrum, a splendid yellow timber. Brazil has a red wood fit for any kind of furniture, the "Echrospermum Balkasarii," and the Dalbergia nigra, a beautiful rosewood. Venezuela has a zebra wood (Cordia zebra); Natal produces sneezewood (Pteroxylon utile), equal

in beauty of grain to the best bird's-eye maple; Canada, its white and pencil cedars (Thuja and Juniperus Virginiana).

It is needless to refer to the ec nomic products of the forests, apart from the actual timber: turpentine, resin, Burgundy pitch from the pine forests of the Lauder; cork from the south of France, Corsica, Algeria, Italy, and Spain; gum animi from Zanzibar; gum copal from Angola and Sierra Leone; gum acacia from Senegal and Mogador; gum arabic from different sources; palm, cocoanut, and other vegetable oils; coir and fibre; bark for tanning; osier and bamboo; corozo, or vegetable ivory, and nuts for turners' work (Phytelephas macrocarpa) from Ecuador; the vegetable wax of the Carnauba palm (Corypha cerifera) from Brazil; caoutchouc, the milky sap of the Siphonia elastica, and other elastic gums, as well as logwood (Hæmatoxylon campechianum), and other dye woods from the same rich vegetable district; bark mat from the bark of the lime, the Russian source of supply for cordage, bags, mats, sandals, bassets, horse-collars, packing-cloths, and other purposes; black and gray moss from Louisiana, used by upholsterers for stuffing; "forest wood" for the same purpose, formed from the needle-like leaves of the pine, essential oil from the same tree, balsam and spice. Such are but a few of what may be called the incidental products of the forest.

Our purpose will have been accomplished if we have succeeded in awakening attention, first to the fact of the invaluable stimulus to art in all its branches, no less than to civil and naval architecture, that must result from the attainment of a competent knowledge of the vegetable kingdom; and, secondly, of the absolute importance, as a branch of the great profession of which the architect, the engineer, the shipwright, and the surveyor, are alike essential members, of the intelligent study of forestry.

FIELD ARTILLERY.

From "Engineering."

We observe, with much satisfaction, that the "Times" has hit the right nail on the head, and hit it vigorously, in its article on French Field Artillery. The article is not the less valuable on account of the fact that in these days of steel and Whitworth metal, bronze has been reverted to by our Government for Indian field guns, and an attempt has been made, not altogether, we believe, without success, to bring us back to bronze field guns in our own army. The chief advocate of the bronze field gun is, we believe, Colonel H. H. Maxwell, R. A., who as the head of the Cossipore Foundry in India, might possibly find his office abolished if new work were not found, and is therefore to be admired for his energy in the matter. With Colonel Maxwell has been associated a few other military gentlemen, forming together a committee, who have settled the matter for us, and persuaded Mr. Cardwell and Lord Northbrook that bronze—a metal of about 17 tons strength to the square inch, at its best, and very liable to failure in casting—is decidedly the best material for guns at present; not, be it understood, for big guns, nor yet for little ones; but for guns of the peculiar size of field guns! A bronze rifle would probably strike ministers as a thing a little out of date; and it is possible that bronze 300-pounders or 600-pounders might do the same; but for field guns, what, ye engineers, can you have better than bronze? We must do Colonel Maxwell the justice to say, however, that not only is he not afraid of being thought a little antiquated in his notions, he is rather disposed to boast of the fact; at least, he thinks other people will find it amusing to see what old-fashioned notions he forms, and gets the Government to adopt, on his advice. Let the reader note well the last two sentences of the following passage from a lecture of his on the subject, at the United Service Institution, which we italicise for the reader's convenience:

"In the present state of our knowledge, the choice of a metal, or combination of metals, for a field gun, appears to lie between steel or steel protected by a wrought iron coil, and bronze. Circumstances may have unduly prejudiced me" [a very candid and proper admission, no doubt],

"but I confess I think there is nothing like bronze for the roughing of a long campaign, nothing like it for simplicity of manufacture, nor for safety from bursting, nor, finally, for economy. *It is curious to look back and to find that I am expressing an opinion held as far back as four and a half centuries. One Capo Bianco, publishing in* 1589, *states that there were bronze guns in existence in* 1418."

We entirely agree with Colonel Maxwell. It is curious—very curious, almost painfully curious—to look back and find that even in four centuries and a half we have made, according to the ideas of a colonel, a military committee, and a British Government, no progress in the production of metals for the manufacture of guns. We wonder if Colonel Maxwell and his patrons have ever heard of the "flint implements" which were used very much longer ago still, for various mechanical purposes. He might, with admirable consistency, provide for the use of flint tools in the erection of the new bronze gun machinery, and then he could write another paper, and tell the great modern engineering world that it would be curious to look back and find that he is now expressing opinions" held as far back s the dateless period of antiquity compared with which one Capo Bianco would be a gentleman of yesterday.

We are obliged, however, to question Colonel Maxwell's opinions in spite of their curious antiquity. In the first place, "the roughing of a long campaign does not appear to us to be the first thing to provide for in modern field guns for European armies. What is primarily wanted is a gun firing projectiles of great range, accuracy, low flight, and what the "Times" (in translating *conservation de la vitesse*) well expresses as "the quality of keeping up the power to hit hard throughout its flight." Even the most casual reader of the reports of the war now raging must have observed that over and over again the opportunity has been afforded, and as often lost, at least by the French, of directing a deadly fire upon the enemy at very long distances. But the French gun is too weak to admit of advantage being taken in these places. The way to get the advantage in such cases is to fire a long shell with the largest powder charge that the gun can consume in its bore. When the gun is strong enough to stand this, you get the range required, in combination with great accuracy, low flight, and great penetration, or a hard blow. But the bronze gun cannot stand it; it is of less than half the strength of the steel gun, and the consequence is that a light shell, which flies high and not very accurately, and is spent before it reaches far, is the only projectile that you dare to fire from it. We are in possession of the report to which the "Times" article refers, and we find these points brought out in it even more strongly than in that article, which we republish on another page. For example, suppose you wish to obtain a range of about two miles. With the French bronze gun you have to give an elevation of about 20 deg., and consequently fire your shell 420 metres high into the air in order to make it reach the distance, and when it does reach, its velocity has dropped from 343 metres per second to 160 metres. The Whitworth ten-pounder steel gun, on the contrary, in order to obtain the same range, has only to be fired with an elevation about 10 deg., and consequently never rises higher than about 180 metres, and when it reaches the two mile distance retains a velocity of 257 metres per second. Military men ought to be the first to secure such overwhelming advantages as these steel guns present, and they would be the first, if they cared less for the past and more for the future.

Colonel Maxwell is equally wrong as to the simplicity of construction of the bronze gun. The successful casting of a number of bronze guns is not by any means a simple matter; and in proof of this we may state that attempts are now being made at Woolwich arsenal to get over the difficulties which attend the manufacture. And partly on account of these very difficulties, it is equally a mistake to suppose that these bronze guns are economical. They are not so; on the contrary, their manufacture is a very wasteful process. A great number of failures in casting occur; a large quantity of metal in excess of the actual weight of the gun—sometimes three times that weight—has to be melted and cast every time a gun is made; and this metal cannot be used over again without an addition of at least 10 per cent. of new metal. The process of casting bronze guns is, in fact, a costly and

uncertain process compared with the manufacture of a gun of Whitworth metal, and this metal, like bronze, can be melted down again as scrap hereafter. The idea that bronze is safer against bursting than the Whitworth metal is absolutely an error, and entirely inconsistent with facts which we and other scientific journals have stated upon the subject.

The fact is, we can make progress in this country in materials and in manufactures—of guns as of everything else; but what it is hard to make way against is that stupidity of the Government which continually invests military men with responsibilities upon questions which they do not understand, and that incapability of the military mind in England—of course with numerous exceptions—to comprehend the real nature and consequences of great improvements until they have first seen them adopted and put in action elsewhere. Their eyes are in the backs of their heads.

BOILER EXPLOSIONS.

From "The Mechanics' Magazine."

Perhaps the most difficult code of laws to enact for the inhabitants of a free country are those whose object is to compel people to take care of their own lives and properties. It is impossible, for example, in a country like Great Britain to enact a statute against extravagance, and where a man comes in for a fortune a portion of his prerogative as a citizen lies in the fact that he may squander his property in such manner as best pleases him. Were this principle confined alone to money matters, or any matters apart from danger to human life, all might be well; but it is not so confined, and as the law so stands at present an employer of labor in many departments of industry may by either his carelessness, his parsimony, or his ignorance, endanger the lives and limbs of his employés without incurring much risk of being called to account in the event of a disaster.

For several years after the introduction of steam as a prime mover it was generally thought, even by clever professional men, that there was something occult, something mysterious, in a boiler explosion; papers were read, pamphlets and books written and published, each and all on this theme, and originating for discussion sundry theories more or less elaborate as to the causes of these explosions. Matters of late years, however, are gradually assuming another aspect. The possibility of so simple a supposition as that boiler explosions, in nine cases out of ten, were easily preventable, begins to receive attention, and the more the subject is investigated the more obvious becomes the plain fact that the inherent causes of these explosions are not to be found in peculiar chemical combinations, spheroidal heat phenomena, etc., but in the placing of a piece of wagon wheel or a bag full of bricks on the safety valve lever, of letting the crowns of the fire-box become red hot, of having boilers "cobbled"—no other word will apply—by any jobber who could knock up a rivet or handle a caulking chisel. Many attempts have been made by Government to remedy this state of things without avail. One great obstacle to legislation consists in the fact that legislation and responsibility in matters of this kind always go together. If Government step into the province of the professional engineer it must assume the responsibilities of the profession, and to do so with safety or efficiency it must obtain the engineer's knowledge and experience. Again, another difficulty in the matter lies in the fact that engineering, of all professions, admits of no fixed rules; it is impossible to draw up a set of rules that will apply more than partially to this question. For example, it is impossible to prescribe by law the pattern of donkey pump to be used to feed the boiler, and it is a matter of difficulty to provide by law that boilers shall never get short of water, be subjected to over-pressure, or be repaired by incompetent men. Any measures to be adopted in the way of legislation on this subject of explosions must be based on the rules of the existing boiler insurance companies, or consist in the severity of the penalties to be incurred by those to whom responsibility would attach for proved carelessness. There cer-

tainly is one point—we will say two—in ch Government not alone can, but ought to interfere ; the one is the question of responsibility of master *versus* man. In most cases this responsibility attaches exclusively to the former, but not always ; several examples will be found where it attaches to both parties—attaching to the master in the careless employment of incompetent men to work their boilers, and attaching to the men who undertake duties for which they are not duly qualified.

The second point calling long and loudly for change in existing laws is the manner of inquiry into what may be termed scientific diasters, such as boiler explosions. We have no doubt that coroners and coroners' juries honestly try to investigate such things to the best of their abilities, but in these matters ignorance is not bliss, and it is therefore folly not to seek out wisdom. In such matters as come within the Board of Trade rules, scientific evidence under certain conditions may, we believe, be called; but a coroner has no such power. Government will generally send an engineer to the scene of an explosion and receive his evidence, but this plan does not go far enough ; there should in such inquiries be a professional assessor on the bench to assist the coroner, and who should have full power to ask questions; these courts, too, should have power to call more than one scientific witness. Nothing gives professional engineers more disgust than the perusal of the reports of coroners' inquests as at present conducted in dealing with questions of science. The questions that should be asked are not asked, and questions are put that are very foreign to the real point at issue.

That, however difficult the task of legislating on this subject of boiler explosions may be, it yet is one that Government can no longer neglect is patent to all observers. The glaring instances of parsimony, of incompetence, and of reckless carelessness that are reported over and over again show the necessity for some amendment in the law. Take the explosion at Leicester the other day, for example. In that case nothing could exceed the either gross ignorance, or worse still, the criminal carelessness displayed by both those who mounted and those who worked that boiler. The evidence of an engineer proved, first, that the safety valve was too small ; second, that the ratio of the lever did not agree with the area of the valve, so that in the first case the valve, even if properly loaded, could not efficiently relieve the boiler if a heavy fire were on and the engine standing, and in the second case the pressure in the boiler would be much in excess of that shown by the spring balance on the lever when the valve was blowing off. There is no more difficulty in compelling boiler-makers to take out licenses to pursue their trade than there is to make physicians or surgeons or solicitors have licenses. Master mariners and pilots must have certificates of competency, and in the event of miscarriage in their several callings they are liable to have their certificates suspended. There is no reason why this system, suitably modified, should not be applied to the makers, repairers, and users of steam boilers. We see patents again and again secured for improved safety-valves, for improvements in feeding-water, and for sundry other contrivances to diminish the chances of explosion ; but, *cui bono?* so long as the commonest and most obvious provisions against these calamities are persistently neglected. We have had letters from correspondents proposing schemes for improved safety valves, and asking us questions as to the reason why boilers should ever explode if provided with proper ones. Is it not, however, folly to expect that elaborate and costly contrivances will be employed when the plain button valve and steelyard are not used as they should be?

Another important point should receive careful attention from the Commission on Boiler Explosions (one, by the way, which we fervently hope will be reprinted next session of Parliament), that of stays. Only too frequently is this part of a boiler-maker's work most shamefully "scamped," and scamped more and more in proportion as the proposed working pressure is lowered ; in fact, as a rule, high pressure boilers are much more carefully made and worked than are low pressure ones, for the simple reason that pressures of 100 lbs. or 140 lbs. per in. enforce attention in a manner that will take no denial. We have heard of a cylindrical flat-ended boiler of considerable size (some 4 ft. diameter) being worked which had not a single longitudinal stay in it. So bad a boiler, indeed,

was it that a practical boiler-maker, called in to examine it with a view to repairs, instantly left the house and insisted on the fire being there and then withdrawn. The trick of fixing lumps of putty on the proper places to represent stay heads, in order to deceive insurance inspectors, is of common occurrence. Cases of Cornish boilers, whose flue tubes are destitute of angle iron strengthening rings, are by no means uncommon. We might fill columns were we to recite the radical defects existing about boilers, working daily and hourly in the midst of crowded streets and workshops. Are they not written in the reports of boiler inspectors? Many of them, we fear, are beyond the reach of any but penal legislation, it being next to impossible to devise statutes of a preventive nature in the direct sense of the term. Still, although the subject is one attended with difficulty, yet we have gained much in stripping it of everything like scientific superstition, and in demonstrating the fact that steam boilers can be used with nearly perfect safety so long as we take care to observe carefully the laws of nature and of common sense.

ELECTRICITY NOT A DUAL FORCE.

By RICHARD HIGGS, B.A.

From "The Electric Telegraph & Railway Review."

Calorimetry teaches us that heat propagates itself through certain bodies with greater facility than through others. Some bodies likewise transmit electrical force better than others; those offering a ready passage are termed, in electrical science, *conductors*, and those offering a high resistance, *insulators*. Conductors and insulators are the same in kind, but differ in degree. Experiment proves that the best heat conductors are the best conductors of electricity. The following table will show the relative conductivities of the various metals :—

	Electricity. Mathiessen.	Heat. Wiedemann.
Silver	100	100
Copper	77.4	73 6
Gold	55.2	53.2
Sodium	37 4	....
Aluminium	33.8	....
Zinc	27 4	28 1
Potassium	20.8	....
Iron	14 4	11 9
Tin	11.4	15
Platinum	10 5	8.4
Lead	7 7	8.5
German Silver	7 7	6 3
Antimony	4.3	....
Mercury	1.6	....
Bismuth	1 2	....

It will be seen that they generally agree as to order, but differ as to numerical relation. This difference may be accounted for by variations in the purity of the metals tested. The similarity in conductivity shows that electrical-force and heat-force are nearly allied. There then remain two theories by which we may explain the transmission of electrical force. Heat is supposed by most physicists to be the *result of the vibration or motion* of the atomic particles composing bodies, and this vibration produces the sensation of heat to our nerves. So far it is easy to follow the theory, but it is further stated that the vibrations which cause heat, take place not only among the atoms of which bodies are composed, but also in an ether supposed to surround each atom. This is difficult to understand, for if we consider gases or air to be made up of atoms, it is next to impossible to suppose that there is some intermolecular medium not made up of atoms, and which is yet not vacuous space, even though we may name it, mysteriously, ether. The other theory is that so ably raised in reply to Faraday's objection, that if space be vacuous it must be an insulator, and there can be no transmission of electricity from particle to particle, and that therefore space must conduct. It has been answered that "if space be an insulator, and if a conducting atom charged with electricity can move through space into contact with another conducting atom, then there can be a transmission of electricity from atom to atom." * In proof of this theory experiment has shown that, in liquids and solids subjected to electrical currents, there is molecular motion.

* Electricity and the Correlations of Electrical Force. Desmond G. Fitzgerald.

We have next to consider the kind of motion imparted to each atom, and here we must be content with theory alone. It can be inductively reasoned that the motion is circular, for as we conceive an atom to be circular in form, we must suppose it to follow the general law that when motion has been imparted to a spherical body, it revolves on its own axis in a direction answering to the line of force; a cannon ball revolves in its passage through the air, and the earth itself in its passage through space. Regarding a conducting wire as a line of atoms, we know that if motion is imparted to one end of the line, it will be transmitted to each succeeding atom till the distant end is reached. Let the reader take a dozen marbles, and place them in a line in the groove formed between the pages of an open book; let the nearest marble be struck, and the motion will be transmitted to the whole line, the last marble rolling some distance away. Let a spring that will always give the same force be arranged, and let the number of marbles be varied. It will be seen that the end marble moves farther away as the number is decreased; affording a good illustration that the force increases inversely as the length of the conducting line. Let now a sheet of paper, or a book, be placed perpendicularly for the end marble to strike against, and the marbles arranged in any number of lines—say three. If the three lines are impelled forward by the same motive power—a pencil held so as to strike the three lines at one time—the three end marbles will be impelled forward to the paper or book. Suppose that it were possible to register this action on the paper as three indentations, each of the same value, made in one second of time, it is plain we should have to impel one line three times—or once with three times the force—to produce the same value of indentation, and three times as fast to obtain three indentations in one second. The first result answers to electrical *quantity*, and the latter to electrical *tension*. We also see that with the greatest *quantity* the greatest amount of *work* is done, the resistance to be overcome being the same. Quantity, then, varies with the area affected; tension, with the number of times force is transmitted in a given time.

Having obtained some idea of the action of an atom when subjected to force, we have next to consider the direction of our force. If we consider electricity as a force, we must consider the normal atomic state to be that of comparative rest. Regarding an atom as a point in a line of force, the force tending towards that atom will be positive or negative to the force tending from the atom; positive and negative being used in the mathematical sense as referring to opposite directions. Electricians have termed that the positive current which flows from the copper pole to the zinc pole, or, inside the battery, from the zinc plate to the copper plate. If the reader will make the following simple experiment, he will see that the positive current is the only visible current in a closed galvanic circuit. Take a battery, and connect a piece of wire one end to each pole; sever the wire at any point, and apply the two ends to the tongue. On the side touched by the wire attached to the copper pole a sharp pricking sensation will be felt, *and on that side only.* Insert a galvanometer between the severed ends, and mark the direction of the index. Join up the severed wires, and insert the galvanometer in any other part of the circuit, the index will still point in the same direction, proving that there is but one current—that from the positive, or copper, pole. It would seem, then, that when electrical force is developed by chemical decomposition, the normal state of rest is destroyed, and force is imparted to the particles of the collecting plate, and thence to line.

There is ground, then, for the supposition that the current flows from the seat of action in one direction only. In further proof, Faraday's experiment with a silver-copper couple may here be quoted. Let two plates, one of silver, the other of copper, be placed in a vessel containing sulphuret of potassium. The needle at first deflects in a direction which shows that the copper is the positive element of the pair; it then gradually returns to its first position, and again deflects in the opposite direction, showing that the silver is now the positive element. After some time it returns, and again deflects in the opposite direction, and goes on thus changing. If the plates be examined during these changes, it is observed that sulphuret of silver is formed when the silver plate is positive, and sulphuret of

copper when the copper plate is positive. Nowhere is there any indication of more than one current. What reason, then, is there to suppose electricity a dual force?—in a closed galvanic circuit we have seen that there is but one force exerted in one direction. The only phenomenon that can be supposed to give rise to the idea that two forces are set free occurs when earth is made to complete the circuit. The battery then appears to draw up a current from earth to zinc—note that the direction is still the same—as well as send a current from copper to earth. Before we suppose another force to account for this flow, let us see if it could not be produced by the already existing force. Imagine that the wire is a tube of water and that, at the point indicated by the battery, a force is applied which imparts motion to part of the water on the tube. We know that the rest of the water will flow in the same direction. To return to our conducting wire: electrical force has been, and is being generated, the atoms in one part of the circuit are impelled forward to the limit of their space, and in their rear, so to speak, a kind of vacuum has been formed, having a tendency to increase, which the atoms in the other portion of the conductor endeavor to fill up, and, in the endeavor, are set in motion.

If this theory be true, it has the advantage in its favor that it does away with the complication of currents so difficult to the tyro in electrical science. Above all should we remember the aphorism, *Natura simplex est.*

Perhaps the greatest phenomenon of electricity is that it both produces and is produced by magnetism. Let us, then, define electricity to be, *a force capable of generating, and being generated by, magnetism.* In a short time, the writer hopes to submit to his readers the application of this definition and of Ampère's beautiful, because practicable, theory to the phenomena of static electrical force, and induction.

PRINCIPLES OF BRIDGE CONSTRUCTION.

From "The Engineer."

Notwithstanding the variety of forms which may be bestowed upon bridges, with all due regard to scientific designing and correct practical construction and the different principles embodied in each particular example, there are but two which can be considered to bear out the signification of the term in a pure and simple sense. They are the arch and the suspension principle. All other forms are either combinations or modifications of these in their outward shape or character of internal strain. The reason that the arch and suspension principles constitute alone perfect types of bridge construction is owing to the fact that they alone are acted upon by one description of strain, provided always that the conditions of theory are faithfully carried out in practice. There is a close analogy existing between the arch and suspension principles—in the difference between their relative shapes, or rather position, and in the difference between the nature of the strain exerted upon them under similar circumstances. The form of the one, and the character of the strain produced upon it, are exactly the inverse or opposite of those distinguishing the other, although the amount of each strain is identical. Obviously, for an entire structure, or any of its component parts, to be strained throughout by any single description of strain, is the most economical arrangement that can be devised. As the nature of the strain—whether tensile or compressive—varies with the principle adopted, the selection of one or the other, theoretically considered, will depend upon the limits of the relative resistances to the strains in question of the material of which the bridge is to be built. Practically, there are considerations which do not allow the dictates of theory to be followed universally in these instances. If we imagine an arch bridge to consist of a single voussoir or ring and a suspension of a single cord or chain, the subject of form and strain is reduced to its narrowest possible compass. In the comparisons of the strains upon these types of bridges—whatever may be their actual contours—they are assumed not to differ sensibly from an arc of a circle. It might be urged

that the arch principle may be simplified by imagining the whole arch to be replaced by a couple of rafters or beams forming the chord lines of the half arches respectively and meeting at the centre. But a moment's reflection will point out that this substitution violates at once the simplicity of the system. A transverse strain is induced on the rafter, in addition to the thrust which results from the portion of the arch principle which enters into the design. A practical example of this arrangement is to be seen in the case of a roof of tolerably large span, in which no ties or secondary trusses, for some reason or other, can be introduced. Each rafter is thus a beam or girder sufficiently deep and strong to carry its own load. Its upper and lower flanges will undergo strains of opposite character, and their calculation, and that of those upon the web, will be determined on the assumption that the design is simply that of an inclined girder.

If we take the analogous arrangement in a suspension bridge, and suppose a couple of tie rods extending from the centre of the span to each tower, the original tensile strain upon the curved chain becomes complicated at once by the inevitable "sagging" of the straight ones. Long unsupported tie rods cannot be used in practice any more than unstiffened struts of similar dimensions. The range of the former very much exceeds that of the latter, owing to the different conditions of equilibrium which are produced in them by the action of their respective strains. If a strut be deflected from its normal position in which its longitudinal axis is in a straight line, the strain induced upon it tends to deflect it still further from that position. But if a tie be placed in similar circumstances, the strain upon it will have a tendency to restore it to its original state of stable equilibrium. Until ties become of considerable length—as occurs in roof trusses, and in those examples of suspension bridges which are designed with straight rods—there is no necessity for stiffening or supporting them. It will be evident, from these considerations, that any attempt, however simple, to alter or modify the strict principle of the arch or suspension type of construction, leads to a direct complication both of parts and strains. The integrity of the two systems is immediately destroyed, a variety of elements being introduced which are completely foreign to the designs, abstractedly regarded.

From these two principles have arisen the numerous combinations that constitute the present practice of bridge-building. All of these differ from the primitive types, in being acted upon by strains of tension and compression, either separately or conjointly. Of the compound forms which embody the principle of the arch in their construction there are two, namely, the braced arch and the bow-string girder. The former of these has been used in but a very few instances, although it is, economically, a sound structure, especially for the employment of cast-iron, as the arch itself, and the horizontal or upper member, are both in compression. A distinction must be made between a braced iron arch and an arched rib, in which the whole strain is taken by the rib. The new bridge at Blackfriars is an example of the latter type. It is true that the spandrels consist of a simple truss of bars, but they serve merely to transmit the vertical pressure to the rib, and do not act as bracing in the sense it is understood to imply when applied to braced girders of any description. There is, practically, no strain upon the horizontal member of an arched rib. It is nothing more than a stringer, and although it is absolutely necessary to the bridge, both as a stiffener and to form a support for the roadway, yet the real resistance is supplied by the rib underneath. The heavy spandrels, the stringer, and the quantity of cross bracing that must be introduced between each separate rib of a structure similar to that recently erected at Blackfriars, cause a bridge composed of wrought iron arched ribs to be anything but an economical specimen of engineering. Another instance of the kind is the Victoria Bridge, carrying the London, Chatham, and Dover Railway and other lines over the Thames at Pimlico. On the other hand, in the braced arch the horizontal upper member does its own share of duty, and the bracing acts according to the correct signification of the term. It is, in fact, a web just as in an ordinary lattice girder, and undergoes strains of compression, or tension, or of both contemporaneously, as the load is partial or uniform, statical or dy-

namical. The other principal modification of the arch form is the bowstring girder, which is exceedingly well adapted for bridges of large span. In this respect it is quite equal, economically considered, and possibly superior to the horizontal lattice, although for limited span the latter is preferable. The bowstring is the arch with the substitution of a horizontal tie for the lateral resistance of the abutments, and the addition of bracing between the bow and the tie or string. The theoretical curve for the bow for a mixed load lies between the parabola and the ellipse, but in practice an arc of a circle is the contour adhered to.

The chief reason that renders the bowstring girder an economical form to adopt in large bridges is, that with a uniform load the strains upon the bracing or web are all of a tensile character. It will be suggested here that so long as the moving or maximum load is considerable, this is no argument in favor of the system, as the bars in the web must be made strong enough to withstand the maximum compressive strains to which they can be exposed. This is just the point we are coming to, and it is here that the length of the span becomes a part of the question. The effect of any moving load upon a bridge, supposing that effect to consist of two components, weight and impact, or, in other words, of a statical and dynamical component, is proportional to the ratio existing between the insistent weight of the structure itself and the moving load. It is the old story of a man lying down with an anvil on his chest, and another man striking it with a hammer, which of course bore a very small proportion in point of absolute weight to the anvil. By similar reasoning, when the moving load bears a small proportion to the dead weight of the bridge, its impactive or dynamical component may be very nearly if not quite neglected, since the moving load per unit of length is a constant, while the weight of the bridge per same unit increases rapidly with an increase in the size of the span; the limit is not far distant when the effect of the impact may be omitted in the calculation. The moving load may thus be considered as a simple addition to the statical load, and the strains calculated accordingly. The bars will be subjected to compressive strains by a partial distribution of the load, but the proportions that have to be given to them by the exigencies of construction will frequently render them more than strong enough to support these without requiring counterbracing. So far as the bracing is concerned, the uniformly distributed load acts in direct opposite to the partially distributed moving load, and it is therefore readily perceived that in large bridges the size of the span may be reached, where the tensile strains due to the one completely nullify those of compression due to the other. While the bracing is thus relieved of a great portion of the strain which falls to the lot of its representative in the girder with parallel flanges, it must not be supposed that it is not resisted by some portion of the structure. It really falls upon the bow or upper flange, but from the shape of this member it is an easy and economical task to stiffen it against compressive strains compared with a long diagonal bar.

Returning to the suspension principle, the modifications of it have not been endowed with the success that has attended those of the other primitive type. Innumerable attempts have been been made by engineers to construct a suspension bridge, simple or compound, which shall be available for railway traffic, but as yet they have all been failures, and in our opinion, always will. We do not mean to assert that it is not possible to build an iron suspension of a very complicated character, which will allow a train to pass over it at the rate of fifty or sixty miles per hour. But we do assert that to do this would cost infinitely more than to erect the bridge upon another and a more secure principle. The difficulty of imparting to a suspension bridge the requisite degree of rigidity to permit of the passage of heavy loads at a great velocity, appears insurmountable. We have not space to mention the many different examples of this form, one of the most recent of which is the so-called cantilever bridges. These are nothing more than a spurious combination of a semi-suspension bridge and continuous girder, and are things to be avoided. They include all the disadvantages of both systems without any of their advantages. Many may be inclined to consider that the horizontal girder, or girder with parallel flanges, has a just claim to a title of its own as a primitive type of construction, as it is not

derivable in form or theory from either of the two which have just been discussed. In this sense, perhaps, it might; but its liability to strains of a double character debar it from that privilege according to the rules already laid down. In whatever particular shape it may appear, whether as a tubular, box, plate, Warren, lattice, trellis, or trough girder, its flanges are both subjected to strains of a different nature, and its sides or web is placed in a similar position. Of these, the tubular may be regarded as obsolete. We shall never build, or at least we ought never to build, another Britannia Bridge. They are costly blunders. The same may be said of the box form, which is only the double plate upon a scale so small that it is impossible ever to examine the girder when it is once riveted up. The "Warren" has exploded for any but limited spans, and would never have enjoyed the share of favor it has, but for the circumstance that it admits of the web being connected to the flanges by pins instead of rivets, and thus offers facilities for erection in localities where skilled labor is scarce and expensive. Regarding the trellis in the light of a burlesque upon the scientifically constructed lattice, we find the latter form and the plate to be the sole representatives of the horizontal or parallel system. There are no varieties of the plate principle, except that the web may be either double or single. But there are many varieties of the lattice girder, in consequence of the different arrangements that may be made with the bracing. Some of these are both unscientific and uneconomical. The web is comparatively the important point in the lattice girder, although the flanges must receive their proper share of skilful treatment as well. An investigation of the merits of the different systems of bracing will form a subject for a future article.

EXTRACTING THE PRECIOUS METALS WITHOUT QUICKSILVER.

From "The Mining Journal."

The great and apparently unavoidable loss of mercury in the extraction of gold and silver from their ores must cause considerable interest to be felt by all engaged in mining for those metals in processes which render the use of quicksilver unnecessary, more especially when, as in the case of the process to which most prominence is given in the volume* just completed by Mr. G. Kustel, M. E., whose works on the metallurgy of the precious metals are already favorably known among practical men, simplicity and economy are combined. The chief aim of the work is to explain the leaching, solving, and precipitation process for silver ores now successfully practiced in Sonora, Mexico, where it has been lately introduced by Mr. Ottocar Hofman; but, to enable those relying upon the book to insure success, he devotes three-fourths of the volume to the consideration of preliminary processes, upon the careful carrying out of which much, of course, depends. Referring to roasting, he observes that, as it is regulated by the peculiarity of the ore, and by subsequent treatment, it is impossible to give any one way which will be suitable in every case. The descriptions of the roasting processes are followed by accounts of the lixiviation process, and of the gold extraction processes, so that a complete hand-book for practical men is thus supplied.

Ores may be classified, Mr. Kustel observes according to the metal the extraction of which is principally remunerative, as silver ores, lead ores, copper ores; according to the metallurgical treatment, as roasting ores, smelting ores, amalgamating ores; according to the predominant gangue, as calcareous ores, quartzose, or ochrey ores; or according to the predominant metallic mineral, as sulphuret ores, chloride ores, carbonates, etc.; and he then gives brief descriptions of the more important silver ores, the difference between real silver ores and argentiferous, and of some of the more important combinations to be met with. Sulphur, he says, is the most formidable obstacle to the metallurgist, in extracting metals from their respective ores. Desulphurization has been a subject of most diligent and numerous exper-

* "Roasting of Gold and Silver Ores, and the Extraction of their Respective Metals, without Quicksilver." By G. KUSTEL. San Francisco, California: Dewey & Co. "Scientific Press" office.

iments. The oldest method is the application of heat, which is still in use, notwithstanding the many attempts in modern times to dispense entirely with fire, or to modify its application, so as perform the process more perfectly, and in a shorter time. The desulphurization of ores is effected by heating, with free admission of air. This is the common way of roasting, and the most important, and is effected either in kilns, heaps, etc., or in reverberatory furnaces; by heating with exclusion of air, only the sulphides of gold and platinum are decomposed perfectly by this method; by superheated steam, and by heating with materials for which the sulphur has a greater affinity. The general effect of roasting is that the metals are oxidized. Only gold and silver are transformed into a metallic condition; and of the silver, moreover, a large percentage is always found as a sulphate, even when the roasting is well performed. The most powerful agent of reduction is carbon (charcoal, coke, etc.,) and carbonic oxide. Metallic oxides in solution are reduced and precipitated in a metallic condition by other metals, or by the aid of electro-galvanic action. Although by mere desulphurization the silver is, to a great extent, converted into a metallic state, this is not always the most suitable condition, except for smelting. It would seem as if metallic silver should amalgamate more easily than if combined with another substance, yet this is not the case. The silver, after roasting, is generally coated with the oxides of volatile base metals, which prevent its ready amalgamation. A momentary contact in a muddy pulp is not always successful. The chloride of silver, however, goes into solution, and unites easily with the quicksilver. Hence in most instances it is necessary to adopt a chloridizing roasting; for this chlorine must be brought in immediate contact with the ore particles. The cheapest material evolving chlorine is salt, from which the chlorine is separated by substituting a substance with a stronger affinity for sodium. In practice, sulphuric acid is used to convert the chloride into sulphate of soda, and thus set the chlorine free. The two principal methods of chloridizing are by roasting the ore with salt in a furnace, and by passing cold chlorine gas through the roasted ore. The silver is easily obtained from the chlorine by melting it with alkalies; the chlorine unites with the alkaline metal, and the silver separates on the bottom of the crucible.

In the chapter treating of the roasting of ores it is explained that in order to chloridize the ore an addition of common salt is indispensable. The salt furnishes chlorine for that purpose and is decomposed by sulphuric acid. The sulphuric acid is created by the decomposition of sulphurets present in the ore. It follows that if silver ore is to be roasted successfully with salt, there must be a certain percentage of sulphurets in it, otherwise no sulphuric acid can be obtained, and consequently, no chlorination, or at least only a very imperfect one, can be effected. In Nevada and Idaho the ore only contains from 6 to 10 per cent. of sulphurets, yet gives a good result. As no pyrites are within reach, the want of sulphuric acid must, when necessary, be made up by the use of some other substance, such as green vitriol or copperas. As to the amount of salt to be used, and when, Mr. Kustel states that ores containing from 80 to 100 oz. of silver to the ton should be mixed with 10 per cent. of salt. Rich ore is often roasted with 20 per cent. of salt. If all the chlorine of the salt could be transferred to the silver, an insignificant amount of salt only would be required for ores containing 100 oz. of silver—not more than 3½ lbs. to the ton; but, in consequence of the different way in which the chlorine decomposes and unites with base metals and gases, the escape of chlorine from the surface of the ore without coming in contact with the silver, etc., a great deal more of the salt must be applied. Permanent stirring is not essential, and Mr. Kustel remarks that a good chloridizing roasting should give over 90 per cent. of the silver converted into chloride of silver, and show as little as possible of base metal chlorides, which are formed under the action of chlorine and hydrochloric acid. When endeavoring to expel the base metals by heat, the loss of silver in presence of much antimony, lead, and copper, should be investigated very carefully. Under certain circumstances it is not uncommon to find a loss of even 50 per cent. of silver if the chloridizing roasting is carried on at a high heat for a great length of time. The formation of base metal chlorides can be avoided by a proper but more expensive roasting. It requires, first,

an oxidizing roasting with the application of steam. This roasting must continue until all the metals are desulphurized and converted into oxides. When this is accomplished, salt and green vitriol are added, and the roasting continued until all the silver is chloridized. There is also a very good way of getting out a great deal of the base chlorides of the ore before the silver is amalgamated or extracted by leaching the ore with hot water.

The importance of a knowledge of the condition in which the metals exist after roasting, is very great to the practical man. Mr. Kustel, therefore, considers it very fully; and with reference to oxidizing roasting, he states that its purpose is either to expel volatile substances which are combined with the metals, as sulphur or arsenic, or to expel volatile metals, which are considered obnoxious to the further treatment of silver ores (as antimony, lead, zinc, etc.). The oxygen has a large share in this transaction, and combines with the volatile substances as well as with the metals. After describing the leading principles of the roasting processes, Mr. Kustel refers, with diagrams and details, to the several furnaces in which the roasting is effected, and then explains the object of leaching. The roasted ore contains chloride of silver, which does not dissolve in water, but generally there are also base chlorides in it, as the chlorides of copper, zinc, lead, iron, antimony, etc., which are soluble. It is the purpose of the first leaching to extract these base metals by means of hot water. The ore is introduced into a square box of pine wood, the planks being 1½ to 2 in. thick. The boxes must be made as water-tight as possible, and provided with a filter at the bottom; in these the base chlorides, soluble in water, are first thoroughly washed out, after which a solution of hyposulphite of lime is led into the tank to dissolve the chloride of silver. The liquid of the second leaching is conveyed through a trough or india-rubber hose to the precipitating tank, of which three or four are employed. The black precipitate of sulphide of silver is conveyed directly into filters made of canvas, either in the shape of pointed bags or otherwise. Mr. O. Hofmann, in need of sulphur for the production of sulphide of calcium, calcined the dried silver in iron retorts, and thus obtained a large proportion of sulphur as a fine sublimate; after this is removed the calcination can be finished with access of air.

But perhaps the most important process described in the book is that of Kustel and Hofmann, by which the roasted ores are so treated that the copper, gold, and silver can be obtained separately. The ore is moistened and then treated with chlorine gas, obtained from a generator of simple construction. The vessel is uncovered, and for a charge of 3 tons of roasted ore the ingredients introduced are—pulverized peroxide of manganese, 30 lbs.; common salt, 30 or 40 lbs., according to quality; sulphuric acid of 66 deg., 75 lbs; and water, 45 lbs. Salt, manganese and water are introduced first, the generator covered, and the hydraulic joints made tight. The sulphuric acid is then charged through a siphon funnel in small amounts —20 to 25 lbs. are sufficient to evolve the chlorine and the required heat. When the evolution of chlorine becomes weaker 20 lbs. more of acid are administered, and after some time the rest of the 75 lbs. It will be necessary now to build a fire beneath the generator, which is placed on tiles, that the heat may not injure the leaden bottom, which is made of 16 lbs. sheet lead, while the sides are of 8 lbs. The chlorine is washed before it reaches the ore, through the whole mass of which the chlorine passes. As soon as the ore box is filled with chlorine, the outlet is closed and the fire withdrawn. In this condition the ore is left for 12 or 15 hours. The gas is then removed into another ore box, hot water is introduced into the first-named box, and the leach run into the precipitating box, where the gold is thrown down in a metallic state by sulphate of iron. The extraction of gold without the use of quicksilver is limited mostly to those ores in which the gold is not free in a metallic condition, but combined with sulphur or arsenic in the respective pyrites.

Although the book contains less than 150 pages, it will afford all the information likely to be required upon the subject and the illustrations of furnaces, implements, and working apparatus are excellent. It gives a condensation of most that has already been published, either in German or English, with reference to the extraction of the precious metals, and contains much that is new in the way of descriptions of inventions to which the

experience gained in the extensive mining operations carried on in the Pacific States have given rise. The merit of the work is beyond question, and as it is certainly as cheap a half guinea's worth as could be purchased by those for whom it was intended, the prediction of the author—that its chances of doing much good are far better than the probabilities of its repaying its author and publishers—is one which happily is not likely to prove true; it will doubtless find an ample number of patrons, both in the Old World and in the New.

THE TREATMENT OF AURIFEROUS QUARTZ.

From "Engineering."

The means adopted for the reduction of auriferous quartz, and the extraction of gold from it, in Victoria, have, it may be justly inferred, been brought to a state of great perfection, when it is remembered with how small a percentage of gold the mines of the Black Hill Company, described last week, are made profitable. The reduction of quartz is a comparatively recent industry, commenced long after the easier labor of surface mining had been established, and at first not only were the means employed crude and primitive, but the processes were very wasteful, and only such reefs were selected for reduction as showed the existence of gold in liberal proportions, such veins only as contained 4 or 5 oz. of gold as a minimum being considered worth working. In those early days the quartz, after it had been quarried, was broken up under the hammer, and this operation was succeeded by the slow and tedious process of reducing the stone, in a mortar and pestle, after which the triturated mass was subjected to a washing similar to that by which the miner in alluvial districts obtained the gold by pan-washing. Reducing mills, shaped after the fashion of coffee mills, were used after the mortar and pestle process had been abandoned, but the first favorable results were obtained with the jigger, a species of rude stamp, the head of which was made of iron fastened to a stem of timber, which was attached to the bough of a tree; the head of the stamp was placed about a foot above the ground, and the elasticity of the bough to which the stem was attached, facilitated the operations of the miner. Of the same class of apparatus was the dolly, a stamp fastened also to a timber stem, and placed horizontally across a vertical post, made with a seat at the top to receive it; the end of the stem opposite the stamp was weighted, and the stamp itself struck upon an anvil placed below. Rude as these contrivances were, good results were nevertheless obtained from them, and they held their own for some time until the Budan stamps were introduced. These consisted of a series of wooden stamps, shod with iron, working in combination with heavy balls, free to move in the amalgamating basin. This machine worked satisfactorily, but it was liable to disarrangement; it required frequent repairs, and the small quantity of quartz it was capable of reducing limited its application to the richer stones, and rendered it unsuitable for meeting the increased demand for reducing apparatus, which the stimulus that had been given to reef mining had received. Invention was soon busily at work, and rapidly one improvement succeeded another; stamping mills of a more effective character were erected by the different companies, until, at the present time, plant sufficiently perfect to accomplish the work required by poor associations, such as the Black Hill Company, has been produced. A few figures will show how great the advance has been in the machinery designed and erected for gold extraction. Thus, at the beginning, the cost of reduction reached from £10 to £14 per ton; four years later it had been reduced from £5 to £8; later again the prices were reduced to 10s. a ton, and we have already seen what can be done with effective plant at the present time. So that, while in the early times only such quartz as showed a rich proportion of gold was worth dealing with, while even those, sometimes deceptive in their quality, failed in the end to repay the cost of reduction, it was found profitable subsequently to work down 3 oz. stuff, then

a quartz yielding 1 oz. per ton, and now stone containing but 2½ dwt. Of course, even at the present time, locality and facilities for working regulate to a considerable extent the minimum percentage it is profitable to work. Two pennyweights and a half, which pay at Black Hill, are refused at Bendigo, where 3 or 4 dwt. quartz are only just profitable, and at Inglewood 1 oz. per ton may be considered the lowest average. It is, however, doubtless only a question of time, for still further improvements to be made in the reducing plant, and the difficulties that now present themselves in different localities to be removed. Then the wide extent of reef already known as gold-bearing, and others which have yet to be discovered, will afford an inexhaustible field to the labors of the miner.

The actual process of reduction and extraction varies almost in every mill, and while each quartz crusher regards his own system as the best, the good results that are obtained by varying means may partly be owing to the familiarity which each miner has of his own method. At the Atlas Company's mine, where the quartz contains percentages of pyrites, the stone is calcined, and then placed under the stamps. The reduced quartz is then passed over the ripple board tables and copper plates into Chilian basins, where the amalgamation is completed. The ripple tables consist of an inclined plane, and from 8 ft. to 14 ft. long, with grooves cut in them at short distances apart, and filled with quicksilver. All the quartz after it has been crushed, passes over these tables, at the lower ends of which are fastened the copper plates, coated with quicksilver, to catch the fine gold from the pulverized quartz. The good results obtained by the Atlas Company were due principally to the use of Chilian amalgamating basins. In the Concord Works, however, results nearly as good were obtained by blanket tables, in addition to the ripples and copper plates. These are inclined planes placed beyond the copper plates, and covered with baize, and they catch the minute particles of gold as the quartz passes over them. The Parker Reef Company employ, besides the ripples and plates, amalgamating barrels. These are mounted on a shaft passed through the longer axis, and they are charged through a square hole in the side, with the material, after it has passed over the plates, mixed with quicksilver. The contents are brought into intimate contact by the continuous revolution of the barrel, and a fresh charge is added every 48 hours. At the mine belonging to the Union Company, Tyrolean mills have been introduced. They are a modification of the Chilian basins, and despite the expenses attending their erection, the whole cost is shown to be recovered by a year's working, owing to the large amount of gold sand, which would otherwise have passed off in the tailings. Other experience has decided in favor of blanket tables in preference to the ripple tables and plate. Thus the Bee Hive Company are using blanketing only. Twenty-four feet of drugget are employed for each set of stamps. They are stretched in three or four lengths, with an inclination of 1 in 16, each length being placed a little below the preceding one, so as to make a series of steps, and give a slight fall to the material as it passed down from the stamps. In this process the only quicksilver required is a little under the stamps. The top length of blanketing is changed every three hours to prevent an undue accumulation of *debris* upon it, the others are worked in six-hour shifts. The time, however, is variable, being regulated by the amount of crushed quartz delivered from the stamps, for as the gold is retained in its slow downward progress by the fibre of the drugget, all that is necessary is to prevent an undue quantity of mud accumulating upon the blanket, and prevent the surface from doing its work. When the druggeting is taken from the frames, the deposits are carefully removed and washed in separate barrels, each length having its own vessel. The washings are also kept separate, and placed each in its own revolving amalgamating vessel, where they are kept in motion of six or eight hours. The result of this process is to bring every atom of gold in contact with the mercury, and effectually to separate it. The greater proportion of the gold is, however, held in the stamping, but the first or highest blanket table yields a considerable quantity, the second length gives but a trifling return, and the third is scarcely worth operating upon, giving only about an ounce of amalgam a week. Experience would appear to decide in favor of this inexpensive

and simple process ; indeed, it was found that out of 5 tons of the tailings from the the stamp mills of the Bee Hive Company, only 8 dwt. of amalgam could be recovered by the costly and finished plant of the Atlas Company, which, as we have seen, is provided with the Chilian mills. Indeed the returns of six months' working by the Bee Hive Company, during which time they crushed 3413 tons of quartz with an average yield of 14 dwt. to the ton, compard most favorably with their previous working.

To see, however, the perfection of economical and effective working, we must turn to the mines of the Black Hill Company. Originally they employed copper plates in conjunction with ripple tables and blankets; but the plates have been for a long while abandoned, and the blanket tables are stretched below the ripples. A small quantity of mercury is placed about every 12 hours into the stamp boxes, and the ripple grooves are also filled with it. Of the gold obtained by this process 60 per cent. is retained in the stamp boxes, 30 per cent. is absorbed upon the ripple table, and 10 per cent is arrested upon the blanketing. At the Clunes workings, ripple tables of a peculiar form are employed. The grooves are wide and deep, the quantity of mercury required is large, and all the crushed material is forced through the quicksilver before it can pass off at the lower end of the table ; by this means the gold is readily separated, while the residue falling on to the blankets is robbed of the small remaining portion of the metal that has escaped the quicksilver. At the Marlborough mines, ripples, plates, and the Chilian mill are employed. A similar system prevails at another mine, where, in addition, shaking pans are used, in which the crushed quartz is placed with the mercury, and the contents are well agitated. At the Prince of Wales mine, Chilian mills instead of stamps are used for breaking up the quartz, and the amalgamation is effected by means of shaking tables and pans. This process gives very fair results, the mills being effective, though slow in their action. We might continue the list of different mines where practice differs almost to an indefinite extent, but we have described the leading methods in vogue. It is probable that different quartz requires different treatment. The richer ores it would appear can be crushed more economically by the Chilian mills, where slow action is adapted to such places as have only a comparatively small amount to be reduced. On the other hand, stamping mills are especially adapted to poorer stones, where a large quantity has to be dealt with, and the greater proportion of gold which escapes the boxes and passes on to the blankets can be recovered by the ordinary method. It has been found that the use of hot water in the reducing mills produces better results than cold. In such localities as give to hand a plentiful water supply there can be little doubt as to the advantage of the blanket system working in combination with the crushers. If, on the contrary, the quantity of water available be limited, then the substitution of ripple boxes with mercury for the blankets is imperative. The stamping boxes should be provided with loose bottoms, or an undue proportion of gold would be carried over on to the ripples and blankets. It is absolutely necessary that the quicksilver employed should be retorted at frequent intervals, as it will not retain more than a certain quantity, and if surcharged the gold passes over and is lost. Until recently it was considered that frequent retorting was unnecessary, filtration being considered sufficient, and considerable losses occurred from ignorance upon this point.

Despite, however, the excellent results arrived at, a considerable waste of gold does often occur, as is evidenced by analysis of the tailings, and invention has been, and is, busy at work, devising means for rescuing every atom of the precious metal. Successful as many of these plans have been upon a small scale, scarcely any of them have answered when put to the test of every-day work at a reducing mill. One system, however, which promises well, has been proposed and largely experimented upon with success. The principle is that of separation by gravitation. A series of four boxes, each of the form of an inverted pyramid, are arranged close to the batteries. The two first of these are of the same size, the third has a capacity equal to the two, and the fourth is double the size of the third. The whole of the stuff, as it flows off from the battery, passes into the first and second vessels, and the fall of the "sludge," from the battery

boxes into these vessels, keeps their contents in a constant motion, that helps to disengage the heavier particles of gold and quartz, and precipitate them to the bottom, where they fall through a pipe, and are passed out upon ripple boxes with deep grooves, through the quicksilver of which all the material is passed, upon the method we have already described. The stuff flowing off the ends of these ripple tables falls into the third and larger box, where a precipitation of the finer particles takes place: and this residue is led off to pass over a second set of ripples, and again to flow into the fourth box. In this are contained the finest atoms of gold, and these are arrested by silvered plates of copper, placed in the box at angles, so as to intercept the particles which are either floating on the surface, or slowly settling to the bottom. In addition to these means, blankets also could be added. It is evident that there are many advantageous features in this plan. It is inexpensive and self-acting, whilst the results obtained from it have been remarkably good.

The presence of pyrites in gold quartz is a fruitful cause of waste, and calcination of the stone has been tried to disengage them, as well as to soften the quartz and make it easier for crushing, but without much success. At many of the workings a great and constant loss ensues from this cause, and but little has been hitherto done to effect the saving. Nay, more, many reefs profitably rich in gold, are yet too full of pyrites to admit of their being worked, while others worked at certain levels, have to be abandoned because the pyrites increase rapidly at low levels. It would, however, seem probable that a means could be adopted of separating the pyrites after the ore was crushed, mechanically and by gravitation. And indeed the apparatus just described effects the object partially, but a perfect means yet remains to be introduced. It need scarcely be said that when this shall be done, the prospect of gold winners from the quartz will vastly increase, while the enormous accumulation of tailings at the different mines will yield a handsome profit upon the labor and outlay of reworking them.

VEGETABLE TEXTILE FIBRES.

Translated from "Comptes Rendus."

Vétillart introduced before the Academy at Paris a paper concerning the differences of the most important textile fibres, of which the following is an abstract as given by Chevreul :

The treatise considers the six most important vegetable fibres : flax, hemp, cotton, jute (*corchorus capsicalis*), Chinese grass (*urtica utilis*), and New Zealand flax (*Phormium tenax*).

The differences are determined by means of microscopical observations of the colors imparted to the several fibres by iodine, in solution of water or sulphuric acid diluted with glycerine. The fibre must be examined longitudinally and transversely. It must be prepared in different ways, dependent upon its condition, whether raw, dressed, or colored. The raw fibre is soaked for half an hour in a weak lye of carbonate of soda, and is then washed ; the dressed is treated with boiling water distilled or slightly alkaline ; the colored is dyed as completely as possible.

A few fibres separated from a bundle 6 @ 8 centim. long are placed upon the object slide of a microscope, are saturated with glycerine or a solution of chloride of calcium to make them transparent, and are covered with a glass plate.

A solution is made with 1 part iodide of potassium in 100 parts of water ; a large drop of this solution is placed upon an object slide, a few fibres are put in it ; after a few minutes the excess of fluid is removed with blotting paper, and a glass plate is put over it ; a few drops of sulphuric acid diluted with water or pure glycerine are applied at the side of the glass cover, and the excess of acid on the other side is removed by blotting paper. All the excess of iodine must be removed in this way.

To observe a transverse section of the fibre a bundle about 3 centr. long of the size of a goose quill is tied around the middle with a thread ; first one end, then the other, is dipped in a solution of lime and glycerine until the lime is uniformly

distributed throughout, the parallelism of fibres being carefully preserved. When the bundle is dry (in about 12 hrs.) it is held in a pair of pincers and cut across by a razor into slices as thin as possible, which are put under the microscope.

The following are the results of observations on fibres treated in this manner.

Fibre of flax which seems single to the naked eye is in fact a bundle formed of united fibres. The elementary fibres can be easily separated by means of a needle. They are from 1 @ 6 centr. long; are uniformly thick; are pointed at the ends, and contain a very minute canal. They are smooth; only those growing from the lower part of the plant being flat and ribbed. Iodine and sulphuric acid dye them blue, sometimes a wine-red; the canal is dyed red. Polygons are observed on the transverse section, which easily separate. These are dyed blue, but yellow at the centre. This slight adherence of fibres, the uniformity of their diameters, and the smoothness of their surface are the reasons that they can be spun into threads containing numerous fibres.

Fibres of hemp are crowded close together, each being surrounded with a thin substance which iodine dyes yellow, not blue. They are about as long as the fibres of flax, but are thicker and rougher; their ends are thick and spatulate. These are dyed blue or greenish blue by iodine and sulphuric acid. Transverse sections of hemp differ from those of flax in the appearance of complexity and adhesion of fibres. Each fibre is colored yellow at the circumference, blue within.

Cotton fibres are always isolated, ribbon-like in the direction of their length, and folded in the middle. Their ends are broad; they contain a central canal, and are dyed blue by the iodine solution. The longest fibres are 25 @ 40, the shortest 10 @ 20 mill. long. In section they always appear isolated and rounded, kidney-shaped. Iodine dyes them blue with yellow spots.

The fibres of jute are closely adhesive, undulating at the circumference and hard to separate; they contain a wide empty canal of varying dimensions, and are flat and rounded at the ends; they are dyed light or dark yellow by the iodine solution. The transverse section presents a polygonal appearance like flax; but the central orifice is larger. The iodine gives a yellow color to the sections, and a dark yellow color to the boundaries of the polygons. Very white jute is dyed dirty blue or green. Moisture separates the fibres. Threads of jute cannot be knit together because they cross at too great an angle, hence its use is limited. They cannot be treated with lye.

The fibres of Chinese grass are isolated and are 5 @ 12 centr. long, while those of hemp seldom exceed 6 centr., are variable in thickness, appear to be ribbed obliquely, and dye blue in the solution. A canal within is often filled with a yellow granular matter which is itself a dyestuff. This wide canal is especially visible in section, presenting very irregular forms and angles.

New Zealand flax consists of the fibres of the leaves of *Phormium tenax*. They are very fine and regular; 5 @ 12 mill. long, and easily separated by a needle. A uniform canal runs through their length. They generally taper at the end. They are colored yellow by iodine. The section is like that of jute; but the corners of the polygons are rounded. New Zealand flax, like jute, must be kept dry, and does not resist the action of lye.

BELGIAN RAILS.—The exportation of rails from Belgium, which greatly increased last year, as compared with 1868, presented but a small farther advance in the first six months of 1870. Belgium exported, however, in the first six months of this year 19,566 tons of rails to Russia; to the Zollverein, 18,318 tons; to Turkey, 12,356 tons; to France, 4,109 tons; to Italy, 3,832 tons; to the United States, 2,999 tons; to Sweden, 1,700 tons; and to Spain, 1,657 tons.

GAS and water works are about to be established at Wellington, New Zealand. The pipes for the water works have already been shipped from England, and have possibly by this time been landed in New Zealand.

RECENT experiments in different places show that an average of 44 per cent. of the rain-fall on a surface of country may be collected in basins or reservoirs.

APPLICATION OF SCIENCE TO INDUSTRY.

From "The Building News."

Dr. Lyon Playfair, in a lecture recently delivered before the Midland Institute of Birmingham, said: "When any tribe or nation can take from another the raw material, which the latter either does not use, or uses with less intelligence, the first nation must be under the guidance of science. The science may be undeveloped, dealing with qualities only and not with quantities, but science it must be; for it is impressing upon the material the conception derived from a cultured intelligence, and making these of a higher relative value than the mere local possession of the material itself. This is the great element of industrial competition in the world at the present time. Take the case of Great Britain in modern days. We have in large quantities, and in fortunate proximity, coal, iron, stone, and lime. We have copper, and tin, and zinc, in smaller proportion. As intelligence arose in this country, and initiatory science became evolved from industrial persuits, the inhabitants no lcnger sold their mineral wealth to distant nations, but manufactured it for themselves. As long as the growing intelligence of our inhabitants equalled or exceeded that possessed by any neighboring nation, our prosperity was secured; because, in addition to the science of the time, the raw material of industry was in our possession, and competition with us was an impossibility. And so it is with all nations. But the moment that any nation allows the intellectual element of production to fall below that of its neighbors, the local advantage no longer suffices for superiority. When commerce and science open up paths of rapid intercommunication throughout the world, the cost of transit of raw material is diminished, and the intellectual superiority of another nation far more than balances the possession of raw material. Roads, railways, ships, and steamboats, arising in the march of science, can spread raw material everywhere, and enable nations to test their relative intellectual powers applied to it. Let us take a case: Cotton being indigenous to Hindostan, calico was made at Calicut. Soon the intellectual culture of the Arabians exceeded that of the Hindoos. Calico was manufactured by them, and introduced into Spain, where it flourished. Then came the great national crime of Spain, in the beginning of the seventeenth century, when a million of the Moriscoes, who still possessed the experience in manufacturing industry, were suddenly expelled on account of their doubtful Christianity. With them, cotton, woolen, and silk manufactures were also ejected from Spain. The 15,000 looms of Seville were thus reduced to 300, and the 40,000 silk weavers of Toledo lost their subsistence as soon as the intelligence and skill of the Moors passed to Tunis. In process of time this country took up the cotton trade which Spain flung away, and made it our own by great mechanical inventions. Not, be it observed, by manual labor, but by the result of intelligence applied to machinery and locomotion. And look how much intellect now exceeds the value of the raw material as a factor in production. Cotton is grown in America, crosses the broad Atlantic as a bulky and expensive freight, is seized hold of by our mechanical science and manufacturing enterprise, crosses the Atlantic again as calico, pays a heavy import duty, and yet undersells the products of the mills at Lowell. When the great American people, through their rising colleges, and by a better understanding of the effects of restrictive tariffs, apply their intellectual powers in this direction, such relative superiority of manufacturing science will be impossible, in the presence of the raw material at the door of their mills. More strange still to see Switzerland, with no seaboard and no coal, bringing cotton from America, transporting it through the defiles of the mountains, then back again over land and sea, in the form of high-priced cotton goods, underselling America in her own markets. What enables such a country to do this? It is not cheapness of labor; it is intellectual or scientific superiority in relation to the manufacture which competes successfully against local advantages. Take another instance. Sweden has excellent iron, and we send for it to Birmingham, where you convert it into tools, axes, chisels, and hoes. You send these to America, though good iron ore

exists in that country. Well, some day the Americans find that by giving a different edge and temper to their axes, or a different form to their hoes, they can do their own work better; so they send to Sweden for the iron, and fashion it into their peculiar forms, and Birmingham does not send so many axes and hoes as formerly, but America actually sends over some to this country, to see whether we like their new forms better than our own. You see that the mere possession of the raw material confers but a small advantage on the country, and that the changes which are continually taking place are not regulated by it. The intellect, which has such a predominant value, receives its expression, at least to a large extent, by incessant efforts to convert the brute labor of a man into an intellectual superintendence of labor performed by a machine. This may be illustrated by any branch of industry taken at random. I see opposite my study window, as I write, a house in course of erection, and the labor of the builder will serve my purpose as well as any other.

An Irish hodman is carrying a quantity of bricks up a ladder, in order to supply material to the builder. The sight is familiar to us still, though not as much so as it was a few years since, because a change is passing over this form of labor. Let us study the reasons for the change. The Irish hodman is a human machine, unskilfully and expensively put into operation. He felt that himself, in his fine, confused way, when he wrote to his friend in Ireland, "Dear Pat, come over here and earn your money; there is nothing for you to do but to carry the bricks up a ladder, for there is a man at the top who takes them from you, and does all the work!" The man at the top is a skilled workman, more nearly fulfilling his human functions, for he is using intellect in his work. The hodman is a worker also, but only a user of his own brute force in a very unintelligent way. Every time that he ascends the ladder with his load of bricks, he is carrying his own weight in addition to that of the bricks; his force is thus wastefully expended. After many years his employer perceives this, and substitutes human labor first by that of a horse, then by that of a steam-engine. Now, when you pass a house in course of erection you will see a horse trotting over a prescribed course. It is pulling up a whole barrowful of bricks by a rope and pulley. The horse, tended by one man, is doing the work of seven or eight hodmen, and with much economy of money, inasmuch as the cost of the hay and oats, from which its power is derived, scarcely exceeds that of the beef, potatoes, and beer of a single hodman; while increased economy of labor is also attained, because the weight represented by the bodies of seven hodmen is not drawn up along with the bricks. Food, burned within the bodies of the men and the horse, is in both cases the source of power. Again, in large houses the horse disappears, and a small steam-engine draws up the bricks. Economy is again achieved, for the coal, which is the food of the engine, is less costly than the hay and oats required for evolution of force in the horse. A single man, using scientific knowledge in the guidance of the engine, is now doing the work of several horses or many men. Let us analyze the changes which pass over the forms of labor illustrated in this particular case. The first tendency is to substitute the brute force of a man by an intellectual superintendence of a cheaper form of force, either animal or physical, the aim being to obtain economy of production, either through economy of time or by the substitution of a cheaper form of force for human labor. In fact, economy of time generally follows the economical substitution of force. Savages have an utter disregard of time in the performance of labor. They will expend a month in sharpening a single arrow. Some of the rock crystal cylinders worn by chiefs for ornaments, are stated to take two men's lives to perforate. The Kamchadals, of North-eastern Asia, take three years to hollow out a canoe, and one year to scoop out the trough in which they cook food. As soon as a savage tribe employs fire, instead of implements made of stone or bone, to hollow out their canoes, they are using a natural power to economize time and brute human force, and are on the high road to civilization. In human progress it is always so, for it is a natural law that the sweat of the brow should be lessened by the conception of the brain. The economy produced by the substitution of cheaper for dearer forms of force is remarkable in all cases

where it is applied. The Prussians saw this very well when they wanted to make England declare coal as contraband of war in the present campaign, that it was representative of so many men added to the enemy; for three or four pounds of coal, even in the wasteful way in which it is used, are more than equal to a man's force. I recollect, some years since, reading an interesting address on this subject by Sir William Armstrong. When coal was first an object of commerce, it was transported on the backs of men from the pit's mouth to the sea-coast. A man, in this way, might carry a load of half a hundred weight; but after a time a pack-horse was substituted for the man, and carried about three hundred weight. As science progressed, the pack-horse was attached to the wheel-cart, into which its load was put, and it pulled down sixteen hundred weight. Then, as industry progressed, tram-roads were laid down between the pit and the coast, and the same horse, pulling a wagon, carried forty hundred weight. Finally came the great triumph of science, when coal was employed to pull itself. The smoking, snorting iron horse, fed with coal and water, drags along the railroad 200 tons. The conversion of coal into force, which produces this great result, is, in point of cost, scarcely greater than that of the human beast of burden, or the pack-horse originally used for a scant result. And yet our engines are so imperfect that they only use one-tenth and waste nine-tenths of the available force in coal! The importance of the transformation may be better understood if you view the force of coal as expressed in men's power; just as we do in speaking of an engine as having so many horse-power. If human force were alone used in this country, the sum of production must be limited by the number of inhabitants. In such a case the United Kingdom could not produce more than the products of the labor of its thirty millions of inhabitants of all ages. But the coal excavated annually in this country represents in actual attainable work almost exactly the sum of the force of the whole population of the globe, viewed as adults. So that the use of a natural force, in substitution of human power, augments vastly the productive resources of our small insular kingdom, and enables it not only to supply its own wants, but also to export to other countries its superfluity of production.

BRITAIN'S STRENGTH.

From "The Engineer."

While "all day long the noise of battle rolls" around us, it is impossible to divert our thoughts from the mighty conflict waged by the two greatest military powers of modern times. The years of tranquillity which followed Waterloo and preceded the International Exhibition of 1851, lulled civilized minds, and led men to believe that the approximate peace of 40 years could not be disturbed by angry passions, the operation of national jealousies, the desire for glory—save the mark!—or a manifested and active desire for national aggrandizement. The dream—'twas but a dream—was readily dispelled, is it necessary to say how? What of the "glorious six hundred?" What of Cawnpore and Lucknow? Swiftly and surely on the epoch of calm followed the period of storm; poor human nature asserted itself, as it will till time is no more, and slaughter and devastation, and the havoc of the dogs of war, slipped once again, racked and distracted Britain. What is the picture before us now? Two little months ago war on a great scale appeared to be impossible. Since last July the civilized world has been carried back; yesterday is a Pharsalia, to-morrow may be an Agincourt, the day after a Balaclava. In this matter of fighting, the world has made no progress since the days when a great teacher told us of the strong man who keeps his house till a stronger than he comes and takes from him all that he has. It is madness—worse, sheer downright idiocy—to believe for a moment that if we would be comfortable, if we would be nationally happy, if we would lie down in our beds in peace, we can be so and do so without being prepared for war. It is an old saying, that "it takes two to make a fight;" just so. But Britain is only one. If France or Prus-

sia had chosen to fall foul of us instead of a nearer neighbor, where would England's strength, riches, glory, or power be now? If we would be at peace we must be prepared for war. The speculations of the Peace Society, the doctrines of men who preach a universal millennium, vanish like chaff before the wind in moments like these. If we would be safe we must be strong. In what shall our strength consist?

All our contemporaries have made up their minds on this point. They can see nothing but great armies in the field and able commanders of soldiers. The power with the greatest army and the ablest commanders wins. "Let us," they sapiently cry, "have great armies and great commanders." In the want of those things lies our national weakness." Nothing is heard of but our weakness; we are feeble in every joint and muscle. This is a miserable wretch of a country, a ready prey for the spoiler; so, at least, the daily press tells us diurnally, and it suggests the remedy—more soldiers. more soldiers. Now, we have not the slightest hesitation in stating that journalists who inculcate such notions as these completely fail to understand in what our weakness and strength really consist. Instead of looking at principles they handle circumstances, coincidences, analogies, imaginations. Their susceptibilities carry them away; their pens are guided by the emotions of the heart, not by the sound reasoning of the head. Because this war is a war of armies, nothing is spoken of but armies. We would adventure large moneys on a wager that if this had been a war between naval powers—a war of ships—not a word would have been said about increasing our army. Every possible pressure would have been brought on the Government to augment our naval forces. Nay, more, although not a word is to be found in the columns of our daily contemporaries about strengthening our navy now, we are absolutely certain that a single naval engagement between France and Prussia of moderate dimensions would induce such a run on the navy as English journalism has never seen. Standing just a little way off from our contemporaries, and possessed of information which they are not expected to possess, let us consider for a moment in what, not Britain's weakness, but Britain's strength really consists.

The strength of Britain lies in four things—her insular position, her wealth, her navy, and the indomitable fighting obstinacy of her people. Of her wealth we shall not speak; of the stubborn courage of her sons we need not tell the story. To the influence exerted by her geographical position and her navy we shall confine our attention.

England, to be safe, must be able to do two things—keep off invaders, and protect her colonies and her commerce. No standing army, no militia, no volunteer force, which a small country like this could possibly sustain save at a ruinous cost, worse than war itself, could possibly prevent invasion and national destruction. The foot of an invader must never be planted on English soil. To secure this end it is absolutely essential that we should possess an overwhelming naval force. Six hundred men in a powerful iron-clad will do more for the defence of this country than six regiments of the line at their full strength. We must set a limit on the number of men told off for defence. Every second man in London cannot be a policeman; every man cannot be a soldier. As, then, our forces are numerically small, and must always be small, put them into ships, where the power of each individual is multiplied by ten. There are but two nations now existing likely to give us trouble, America and Prussia; it will be years before France contemplates invasion. What must that fleet be which can carry 100,000 men across even 20 miles of water and land them on a hostile shore in the face of even a small army? The only chance of success would lie in a plan like this: The enemy's transports would lie, say in Cherbourg, Havre, and one or two other towns on the French coast. The troops would be quietly put on board. Meanwhile, a fleet of iron-clads would sweep the Channel clear of English ships, and then guard the Straits of Dover on the one hand and the chops of the Channel on the other, so that no other fleet could enter. At the proper moment the transports would steam across and prepare to land troops on 2 or 3 unprotected places on the coast, while the iron-clads would close up on either side to cover the landing; under such circumstances we believe

a landing would be effected do what we could. If the Prussians attacked us their policy would be much the same. The German Ocean would be pretty well scoured by iron-clads, and our ships driven off. The transports would then throw their troops ashore under fire of heavy guns. All this is plain sailing, and looks very nice on paper; but even on paper it is obvious that the whole success of the invading army absolutely depends on the absence of English iron-clads at the time of invasion. Being present, the transports would be sunk, buried, and destroyed in an hour if they were unarmed. If iron-clads were used, it would be impossible for them at the same time to engage the shore, our iron-clads, and land troops in boats. The most helpless and unmanageable creature in existence is a soldier, especially a foreign soldier, in a boat. Probably sea-sick, certainly wretched after the passage, the invading army would be comparatively helpless. Pounded by light artillery and riflemen from the shore, without the power of firing a shot in return, troops so landed would simply be thrown away. But how would the case stand if our fleet were driven off boldly or kept engaged by a more powerful force? The enemy's guns would effectually silence any batteries we could bring to bear, just as the Confederates were silenced by the monitors at Fort Fisher, and the troops would be landed, and fed, and refreshed before they marched inland. It is all very well to talk about our fortifications, but no enemy would be fool enough to go near a fortification; he would pick out quiet spots, such as Sandgate or Herne Bay, Margate, Bournemouth, or Folkestone. Nothing we could do would prevent invasion if our ships were beaten. No invasion is possible so long as we have information enough of the enemy's movements, and ships and men enough to baffle and defeat the aims of these movements. It is to the augmentation of our fleet and their crews that we must look for national safety; for the avoidance of such a disaster as that which has befallen France. In England's fleet lies Britain's strength, and we are happy in the knowledge that no other nation in the world—thanks, we say with all honesty, to Mr. Reed—has a fleet so powerful, or—thanks to Woolwich—has so mighty an armament. But we have neither ships, men, nor guns enough to protect at once every portion of our coast and our commerce. On this point we may state that we believe it to be an entire fallacy to believe in any case that if we have ships enough to cover every probable point of attack on our own shores we have all we want. Nothing of the kind; our policy must be, not to watch our own shores, but the enemy's; we must do as Nelson did—never let a hostile fleet out of port without the certainty of a naval engagement. Our commerce cannot be injured, our colonies cannot be attacked by any European Power—except Russia marching on India—so long as we allow no hostile ships to get out. We ought to have ships enough not only to patrol the seas and pick up stragglers, but to watch every port of a foe where it is possible he could fit out a fleet. The mischief must be nipped in the bud or not at all.

We believe that this is comparatively a novel aspect in which to put our national position, but it is the only true statement of that position. Let us hope that we shall find sensible men, as soon as the first flush of the novelty of the present war has worn off, raising their voices and using means to induce Government to strengthen our navy. It is right and proper that our army should be augmented. It is essential that our volunteers should be supplied with breech-loaders. There is not a coast-guard station in the country where a battery should not be erected and one or two guns mounted. We have thousands of cast-iron guns lying at Woolwich which are useless against iron-clads, but properly handled, and used with grape or canister, would tell fearfully on the crews of boats attempting a landing. These little batteries disposed at close intervals would serve to train up a body of first-class gunners among us if they did nothing else. Remember that they are not wanted to operate against ships, but against boats packed as full as they could hold with troops. But neither a standing army, coast batteries, nor volunteer riflemen, can give us security. That for England lies in her great navy, and in that alone.

THE 112th Asteroid was discovered recently by Prof. Peters, of Hamilton College. It is to be called Iphigenia.

A JOURNEY INTO SOME OF THE IRON-MAKING DISTRICTS OF THE CENTRAL PROVINCES OF INDIA.

From "The Mining Journal."

In several places in India I had frequently met with iron slags and furnace cinders, evidences of the past existence of native smelting works, and often had I felt and expressed a wish that I might some day fall in with the native iron smelters at their work, but it was not until a short time ago that this wish was realized.

Leaving Chanda by the road to Moohl one has to pass through about as dense a jungle as Indian traveller ever meets with—a jungle growing out of the soils and clays of coal-bearing sandstones, or at any rate of sandstones beneath which other sandstones bearing coal seams occur. These sandstones continue for more than 20 miles eastward of Chanda; and Mather and Platt's steam boring machine, worked by Mr. W. P. Mather, is now steaming away in the jungle, for the purpose of ascertaining particulars as to the occurrence of coal seams below.

Chanda is not only the name of an Indian town in this part of the great empire, it is also the name of a large district in the Central Provinces, and since the discovery of coal by the indefatigable Deputy-Commissioner, Major C. B. Lucie Smith, it is also the name of a coal field Westward from the town, and at a distance of about 15 minutes, a pit has been sunk to coal; at about 80 ft. deep a four-foot seam of good coal was passed through, and about 12 ft. below this a seam of upwards of 30 ft. in thickness has been penetrated. The Viceroy of India, Earl Mayo, descended this pit on March 1 last, and inaugurated Chanda coal mining by hewing a piece of coal from the large seam. His Excellency on returning to the surface graciously granted permission to name the pit "The Mayo Colliery," and a village near to the pit is to be henceforward known as Mayo Town. In referring to the coal and coal mining in this way, I have not made an unnecessay digression.

We started on our journey from Chanda to Moohl in an easterly course; Mr. Mather, disturbing the stillness of the jungle by his steam borer, was passed about three miles from Chanda, and the coal-bearing sandstones were left behind us at a distance of something over 20 miles. Associated with the coal measures sandstones, there are bands of highly ferruginous rock, from some of which I fancy the native smelters have at one time taken iron, as furnace slags are met with near them. I hope to have a variety of them assayed for the metal, and some of them analyzed with a view to their suitability as ores for reduction on a large scale. Here, too, as in many other parts of India, are the wonderful laterite beds, locally known as "mooruni." At Chanda itself, on the Moohl road from Chanda, and at the Mayo Colliery, to the west, these beds occur close to the surface; they vary in thickness from a few inches to many feet, and consist mainly of a coarse ferruginous gravel, which in Britain would doubtless be used as a source of iron. You will see from the map that our journey from Chanda is towards one of the great feeders of the River Godavery—the Weingunga; but some miles before coming to this we have left the coal field behind us, and are now in regions of metamorphic and gneissoze rock. Our route now, too, is more northerly than westerly. At the small village of Chicklee, on this, the western side of the Weingunga, the native iron smelting furnaces were for the first time seen; it was to me, as I have no doubt it would have been to most of the readers of the "Mining Journal," a sight of great interest, and curiosity. I had formed but a very imperfect notion of the mode of operation of iron smelting by Indians from what I had heard and read, and for the benefit of others who may have formed similar notions I shall make a description of the operation clear by a few illustrations. The simplicity of the mode is vastly amusing, and an old dusky son of Vulcan was very indignant at my inquiring if there was any other method employed for iron smelting than the one we were witnessing. His reply was, "What other way can there be?"

The furnaces are built of mud and stone, and their interior, or crucible, is repaired by mud and cow-dung after every "draw" of the metal. The inside of the furnace

is a truncated cone of about 14 in. in diameter at the base, and 4 in. at the top or truncation. The outside is from 5 to 6 ft. in height, has a base of about 3 ft. 6 in. in diameter, and slightly tapers towards the top. The blast is produced by 1 man working a pair of bellows, or by 2 men each working 1 large bellows. The small ones are simply goat-skin bags, made at one end to taper to a small burnt clay tuyere, and at the other provided with a pair of wooden lips, on which small straps are fixed for the operator's hand. In drawing the bellows out to fill with air, the lips are kept open; then they are suddenly closed, and a skin-full of air forced into the furnace. As the right-hand bellows is pressed inwards to discharge its load of air into the furnace, the lips of the left-hand one are opened, and drawn outwards to receive its load, and *vice versa*. Thus as the hand holding one skin closes up the lips and presses inwards, the hand holding the other opens the lips and draws outwards, and by this means a continued blast is produced. The operation, simple as it seems, requires considerable practice before it can be done with the rapidity required. The blast for all the native smithies and forges is produced by the same means, and often one sees the wife or daughter working the skin for their relative "the village blacksmith." The iron ore is broken up into very small pieces preparatory to its reduction in the furnace, and after the furnace has been well heated, the ore and the charcoal are mixed together, in proportion by measure of about 1 of the former to 5 of the latter, and then poured into the furnace from the top. After blowing for about twelve hours, the skins and the wooden stool on which they rest are removed, the tuyere holes closed up, and the furnace tapped just below the tuyere holes to let off the slag. The mud and small stone wall forming the side of the crucible under the tuyere holes, is then removed so as to make an opening of about 1 ft. in area, and the metal, which now looks like a lump of cinder, is withdrawn by large tongs, and hammered, as it is being rolled about on the sun-hardened earth. After this operation is completed the mass, weighing from 20 lbs. to 25 lbs., is cut nearly into 2 parts by a common native hatchet, so as to show the quantity of utilizable iron it is likely to yield, and then it is ready for the market, so far as the smelters are concerned. Occasionally, when the proportion of cinders to metal is large, the mass is re-heated in a rudely-made hearth, and rolled and hammered as before. In this state it is bought by blacksmiths in the vicinity of the furnaces and forged into small bars, 6 to 8 in. length, and fron $1\frac{1}{2}$ to 2 sq. in. in cross section, and then sold at local fairs and bazars to the village smiths for making agricultural implements, cart-wheel tyres, the small hatchets for wood chopping which one sees on the shoulder of every native "clodhopper," and various other things of minor demand, as nails, spikes, clasps, etc., used in native hut-building.

From what has been said, it will be seen that no flux is used. The ore used in this part of India, is a rich magnetic oxide, which on assay by the Government analysist in Bombay yields 68 per cent. of metallic iron, showing that there can only be from 4 to 5 per cent. of earthy matter to get rid of in the blast furnace. Goonjwye is the first place come to in journeying from Chanda, where iron ore is being mined by the native smelters. Here shallow lodes are being dug at the foot of a hill, and the ore obtained in small fragments under from 2 to 3 ft. of surface earthy debris, and extending over a range of several hundred feet from the hill, and along one side of it. In ascending the hill from this range, and until reaching the top, a height of about 50 ft., and up a slope of more than three times this distance, I found that every piece of stone one could possibly pick out of the thick jungle was a piece of highly magnetic iron ore. At the top of the hill the ore presents itself in huge blocks, lying in and on the edges of a natural quarry, one side of which consists of hard gneiss, and forms the hill flank opposite to the one, by which I ascended. From this quarry, or crater, one may reasonably surmise, have been forcibly expelled by volcanic blasting the fragments of ore now found at the base of the hill, and from which the native furnaces in the vicinity are supplied; and the wall of gneiss so well defined, and although seen for only a short distance owing to the jungle, indicates the presence of an iron ore lode.

I must here say a word or two about the interest one cannot help feeling in a spot like this, apart from geological or

mineralogical questions. Where the large blocks of ore and of gneiss are heterogeneously scattered, and Vulcan has himself mined or quarried on a scale far surpassing human efforts, an open space is formed, and is closely surrounded by trees, and these again filled in about their trunks with smaller jungle. It is to such places the native Koonbees and Gonds are drawn by sacred influences to perform their religious ceremonies, and at such places where, perforce, one feels as if in Nature's own cathedral. Here, for many a year, on the special annual feast day, must the native devotees have brought the image elephant, formed out of plastic clay and baked into hardness, and through this emblem of power worshipped the Deity, as many an image, perfect, and in various stages of decay, and the wreck of many more, are heaped together in front of the massive stones. And then, as in every such place where Nature's work has been done in a manner to attract imposingly, superstition, through long traditions, has peopled the spot with visitors from the dead, or from regions of inhabitants of habits and intelligence differing widely from those of earthly and human kind.

Lohara is situated about 50 miles north-east from Chanda, and about 11 miles north by west from Goonjwye, and at this place, as at Goonjwye, there is a hill of the same kind of iron ore. For about 100 yards, through jungle, and on the slope of the hill from base to summit, one has to walk over fragments of magnetite; specimens of no other kind of rock can be found. The "expression" of the place, as regards the quantity of ore easily obtainable, seemed to me to excel that of Goonjwye. The natives dig for the ore here as at the other place, near the base of the hill, where they find it in small pieces, and thus save labor in breaking it up for smelting. In one place a sinking has been made to a depth of about 20 ft., on a kind of lode of the ore, and widened out into a large space, but this can only have been led to by finding small pieces in such places, as there is a vast quantity of the ore exposed at the surface in large pieces and masses. There is, I think, a probability that the ores here and at Goonjwye are elevated portions of one and the same large lode; as at Dewalgaon, the third and last place I inspected, there is unmistakably a lode of the same ore clearly traceable for at least 150 yards, and running nearly parallel with a line uniting Goonjwye and Lohara. The cardinal lode is about 10 ft. wide, and is filled up with nothing but massive ore; there are, however, forks and branches from this, and small pieces of the ore are scattered over the country for many square acres in extent, as is shown by the various diggings for it for the native furnaces. This place is on the east side of the Weingunga river, and at least 30 miles further from Chanda coal field than Goonjwye or Lohara.

From the Mayo colliery to Goonjwye, or to Lohara, the road is about 65 miles; the roads are good ones for native carts, that is as compared with Indian roads, and, save during the rains, the ores could be carted from the mines of iron to the present only mine of coal in the district for about 12s. per ton. To this sum would have to be added the cost of breaking up the ore at the mines, and filling it into carts, for which I think 2s. per ton would be sufficient. A very large quantity of ore is obtainable in fragments—many hundreds of tons—to load which into carts would not cost more than from 2d. to 3d. per ton; but for breaking up the large blocks, drilling machinery and blasting by gunpowder would have to be resorted to, and would, of course, increase the cost. It is hoped that coal will be found nearer to this valuable ore than the Mayo pit, and then with narrow gauge and cheaply made railways, and Fairlie's bogie-engine train, what may not be done in the way of economic transit of material? No one is more keenly alive to the importance of iron-producing works in India than His Excellency the present Viceroy, the Earl of Mayo; and now that railway extension is to be made on a somewhat extensive scale, it is the flood-tide of time "which if taken will lead on," etc., so far as regards iron works, and His Excellency the Viceroy is wishful to make rails in India for Indian railways, and other requisites in iron material, and why should they not be made, and made, too, in this part of India, when we have the best iron ore in the world, and a fair quality of coal so nearly together, and there, too, are limestone in abundance close at hand?

ON PYROMETERS.

BY C. WILLIAM SIEMENS, F. R. S., D. C. L.

From "The Artizan."

The mercury thermometer which enables us to estimate ordinary temperatures with such admirable precision, fails to indicate heats exceeding the boiling point of mercury (500 deg. Fahr.), and although many attempts have been made to produce a reliable high temperature thermometer (or pyrometer), it can hardly be said that such an instrument is now in the hands of the practical metallurgist.

Amongst the attempts which have been made in this direction the Wedgwood pyrometer occupies the first position. It is based upon the peculiar property of fire-clay to shrink permanently when exposed to intense heat, and upon the supposition that the amount of shrinkage in question was proportionate to the intensity of the heat to which the ball of fire-clay had been exposed. The error involved in this supposition becomes at once apparent if we consider that the shrinkage of the ball is caused by the expulsion of water of hydration which must necessarily take place chiefly at one particular temperature. It is proved, moreover, by the very discordant and, in fact, impossible results, recorded in chemical works as being obtained by means of this instrument. Thus we find it stated in Dr. Lardner's popular treatise, that cast iron melts at a temperature of 17,977 deg. Fahr., and that iron welds at a temperature of 21,000 deg. Fahr., whereas it can be proved that the utmost temperature to be obtained by the combustion of carbon with a blast of atmospheric air, cannot exceed 4,600 deg. Fahr., which degree of temperature far exceeds the points of heat to be met with in metallurgical processes, not excepting even the melting point of mild steel, which comes nearest to the maximum point here indicated.

Amongst the other pyrometers that have been proposed from time to time is the air pyrometer, which is limited by the melting or softening point of the vessel confining the air; the pyrometer by difference of expansion of two metals which has lately been brought forward in a compendious form by Mr. Gauntlet, but which cannot be relied upon beyond a point approaching red heat, at which permanent elongation of the metal sets in; and a pyrometer by contact of two dissimilar metals setting up an electric current capable of measurement, which, however, is by no means proportionately progressive with increase of temperature.

Another pyrometer has been based upon the well-founded supposition that the specific heat of metallic bodies is the same at various temperatures, and that by measuring the heat of a ball of metal after it has been exposed to the heat to be estimated, a true measure of its intensity is obtained. I have myself constructed an instrument upon this well-known principle, which has found considerable favor with ironmasters in measuring the temperature of hot blast, and for other purposes. It consists of a portable vessel composed of three concentric cylindrical vessels of thin copper-plate, the two interstine spaces being filled; the inner one with cow-hair, and the outer one with atmospheric air, and the two together forming an excellent barrier against loss of heat from the interior of the vessel.

A delicate mercury thermometer is fixed in the interior of the vessel, being protected by a perforated shield, and furnished with a movable sliding scale showing pyrometer degrees, of which one is equal to 50 ordinary degrees. The instrument is accompanied by balls of copper or platinum, which are so adjusted that 50 of them would be equal in thermal capacity to an imperial pint of water. Each ball is perforated by a hole through which a rod is passed in exposing the same to the action of the heat to be measured. Immediately before using the instrument, an imperial pint of water is poured into it, and the pyrometer slide is so moved that its zero point coincides with the top of the mercury column in the thermometer tube. The ball is thereupon exposed to the heat for two or three minutes, and plunged into the water. The mercury will be observed to rise, and the absolute temperature of the place measured is ascertained by adding the reading on the pyrometer scale, opposite the new level of the mercury, to the degrees of temperature indicated by the thermometer before

the ball was introduced. In using ordinary dexterity very satisfactory readings may be obtained with this instrument, but its application is limited to the point of heat at which the metal ball employed begins to deteriorate, nor can it be employed for measuring the temperature of inaccessible places.

It has been my endeavor for several years to devise a pyrometer of a more universal applicability, and containing in itself more absolute proof of correctness, and, after a long series of experimental investigations, I have succeeded in producing an instrument which I can confidently recommend to the practical metallurgist. It is based upon the peculiar properties of the pure metals to offer an increasing resistance to the passage of an electrical current with increase of temperature. A platinum wire of known electrical resistance is wound upon a cylinder of fire-clay, upon which a helical path has previously been cut to prevent contact between the turns of the wire. The coil of wires, so prepared, is enclosed within a cylindrical casing of platinum, if the temperatures to be measured exceed the welding heat; or of iron or copper if lower temperature only requires to be measured. The two ends of the coil of wire are brought out endways and are attached within the protecting tube to thicker leading wires of copper, insulated for a short distance by being passed through pipe-clay tubes, and further on by india-rubber, or gutta-percha, terminating at the measuring instrument, which may be placed at any convenient distance. This latter is of peculiar construction, its characteristic feature being that the usual calculations necessary in determining electrical resistances by the Wheatstone or other methods are dispensed with, and a reading in degrees of a large scale is at once obtained by so placing the index lever that the electrical current, generated in a small battery and passed through the measuring instrument, including the platinum wire of the pyrometer, produces a deflection of the galvanometer needle. These degrees do not express the temperature, but the temperature they represent is expressed by the accompanying table of reference, which has to accompany each instrument. The pyrometer coil itself, with its protecting casing, may either be fixed permanently at points, the temperature of which ought to be ascertained from time to time, or it may be introduced into a furnace through a door or aperture for only a minute or two, which time suffices to obtain a reading of the instrument. The latter is the only practicable method where the temperature to be measured approaches a welding heat which would in time destroy the protecting case of platinum or any other material; whereas, the former method of fixed coils will be the most convenient for measuring the lower temperature of drying or annealing stoves, or of the hot blast supplied to blast furnaces. At iron works with a number of hot blast stoves, protected coil may be fixed within the hot blast tube leading from each stove towards the blast furnace, and the leading wires from each of these coils be brought into the office where the measuring apparatus would be placed. By such an arrangement the temperature of the blast of each stove of the furnace could be measured and noted at frequent intervals by a clerk without leaving the office, and very perfect record and control be thus obtained. The correctness of this instrument depends solely on the ratio of increase of electrical resistance in the platinum wire with increase of temperature. This rise is considerable, the resistance being increased fourfold by an increase of temperature from the freezing point to about 3,000 deg. Fahr. The ratio of increase is, however, not uniform, but follows a parabolic law which I have ascertained by a series of careful observations embodied in the table, and which form the subject of a separate communication to the Royal Society. I wish it to be understood that in developing these principles, I have been animated solely by a desire to fill up a blank in the means at our disposal to carry on metallurgical inquiries with such a degree of certainty as could not hitherto be realized without seeking for any commercial reward, through the Patent Office or otherwise.

A STEAM omnibus has began to run regularly between Edinburgh and Portobello, a distance of about 3 miles. The omnibus is constructed to carry 65 passengers—21 inside and 44 outside. The trips already made have been very successful.

THE SHERMAN PROCESS.

From "Engineering."

During the past few years the iron-making public have had brought before them so many "processes" for purifying iron or manufacturing it into steel, with more or less wonderful results, that the advent of a new process, unless it be one possessing more than ordinary claims to notice, has almost ceased to attract any general attention. Notwithstanding this, however, it is an undoubted fact that there is still ample room for improvements in our various methods of iron and steel making, and particularly is there wanted a means of turning to better account the low class irons produced in many districts. Amongst the many workers in this field is Mr. J. Edwin Sherman, who has lately arrived in this country for the purpose of introducing here a "process," of which he is the inventor, and with which, it is stated, very successful results have already been obtained in America. Mr. Sherman has visited England at the invitation of our Government, conveyed through the British Legation at Washington; and the earlier trials of his process made by him since his arrival here were conducted at the request of the Lords Commissioners of the Admiralty and partly under the supervision of one of their officers. Before speaking of these trials, however, let us give what information we can concerning the "Sherman process" itself. And here we may acknowledge at once that this information is exceedingly scanty, so scanty, indeed, that had it not been for the importance of the object which the process professes to attain, and the satisfactory manner in which some of the curious results already obtained by it are vouched for and certified to, we should have hesitated to bring the "Sherman process" under the notice of our readers at all. It is true that Mr. Sherman has patented his process in this country, but as his patent was only taken out on the 25th of July last, it will not be open to inspection until the 25th of next January, and in the mean time its owner prefers to keep its details secret. All that can be said, then, is this: In applying his process to the purification of iron in the puddling furnace, Mr. Sherman melts the pigs in the ordinary way, and then, just at the moment that the "boil" is commencing, he throws into the liquid metal a small packet containing certain chemicals, of which he at present keeps the composition to himself. The effect of this addition is stated to be an increased fluidity and boiling up of the metal, and a rapid throwing off of impurities, thus enabling the iron to be more rapidly "brought to nature" and materially shortening the time occupied in the operation of puddling. The dose of chemicals, or as it has been named by the men, "physic," is so small, and apparently so utterly inadequate to the results claimed to be produced, that it is not to be wondered at that the whole process has been regarded in many quarters with considerable incredulity—an incredulity which we believe nothing but an inspection of the results actually obtained in practice is likely to remove. In applying the process to making cast steel in pots, the chemicals are placed in the crucibles with the iron; while in employing it for rendering common irons available for the Bessemer process, the "physic" is by preference added to the liquid metal as it is being run into the converter, although it is stated that it may be placed in the converter itself, or even in the ladle from which the steel is poured.

So much for the general outline of the "process;" and now for the results which it is stated to produce. Mr. Sherman asserts that by his method of treatment he can "add materially to the value of the best pig-iron made in this country," while he also states that he can produce from the common brands, without admixture of higher class pig, iron which has been pronounced equal to "best best" Staffordshire; and that from cinder and other low grades of pig, each worked separately without mixture with other brands, he can by his process produce good merchantable iron of uniform quality. Further, he affirms that he can produce good tool and other steels of very high tensile strength and ductility, and of uniform quality, from the common pig-irons of this country. These are

certainly startling and apparently somewhat bold statements; but the results which Mr. Sherman has already obtained warrant our regarding them with far more attention than we should otherwise probably be disposed to vouchsafe to them. Mr. Sherman, moreover, offers to prove the accuracy of his statements at any iron or steel works where the necessary facilities and a fair trial will be offered to him; and inasmuch as the application of the process involves no alteration of furnaces or general system of working, there is every reason why his process should be exhaustively tested.

Mr. Sherman's first trials in this country were made, at the request of the Lords Commissioners of the Admiralty, at the works of Messrs. Vickers, Sons, and Co., of Sheffield, and consisted in the manufacture, by his process, of steel ship-plates and samples of tool and other steel, from common English irons. The plates were made from irons selected by Mr. Luke, the Chief Surveyor to the Admiralty, and, the experiments having been conducted under his supervision, the plates were stamped by him, and sent to Chatham Dockyard for the purpose of being tested. The results obtained were very satisfactory, the samples showing a tensile strength of 36 tons per square inch of original section with an elongation of from $1\frac{1}{2}$ in. to $1\frac{13}{16}$ in. in a length of 6 in. The breaking strain, calculated from the reduced area at the point of fracture, was over 60 tons per square inch. Further samples of these plates, which were $\frac{7}{16}$ in. thick, were bent double at a dull red heat, both with and across the grain, without showing signs of fracture, while a piece was also bent double cold, with the grain, with the same result, and another piece was similarly bent *across* the grain with but very slight fracture. Another of Mr. Sherman's samples tested at Chatham, was a $1\frac{1}{2}$ in. square bar of a tough class of steel, named by the Admiralty officials "gun metal." This bar proved to have a tensile strength of 59 tons 645 lbs. per square inch of original section, and its elongation was $5\frac{1}{8}$ in. in a length of 2 ft. This bar was also bent double *cold* without sign of fracture, and a portion of it forged down to $\frac{1}{2}$ in. square, broke with a tensile strain, on the reduced area, of 66 tons 840 lbs. per square inch, the elongation being $1\frac{5}{8}$ in. in 1 ft. Another sample was a piece of tool steel which broke at 73 tons, 755 lbs. per square inch of original section. Tools of various kinds, made of this steel, were tested at Chatham with most satisfactory results. The various samples of which we have spoken, as well as those to which we shall refer hereafter, were, we may mention, exhibited by Mr. Sherman at the recent quarterly meeting of the iron trade at Birmingham, and much attention was attracted by them. Altogether, about fifty samples of various kinds of iron and steel produced by this process were shown.

The application of the "Sherman process" to the production of steel by the Bessemer process from common brands of iron, has been tested at Messrs. Lloyd's, Foster & Co.'s works at Wednesbury with promising results; but the trials were not sufficiently extensive, nor are the data in our possession concerning them sufficiently detailed to enable us to speak of them with any degree of decision. Mr. Sherman is, however, we believe, now conducting some further trials at Sir John Brown & Co's works at Sheffield, which will, we have no doubt, supply the information we desire. The possibility of purifying iron by the Sherman process has been tested at the works of the Darlaston Steel and Iron Company, near Wednesbury, under the supervision of Mr. E. T. Mainwaring, the manager of the works, and judging from samples now in our possession, and which, it is stated, have been produced from common brands of iron, the results are very satisfactory. In this case, however, as in the case of the experiments at Messrs. Lloyd's, we should prefer waiting for more definite information as to the precise nature of the pigs treated, before offering any decided opinion on the value of the results obtained. At the Darlaston Works, also, a few ingots of cast steel have been made from the puddled bars produced by the Sherman process, and this steel has been found to make good tools capable of standing severe trials. One piece of this *tool* steel now in our possession has been drawn down at one end to $\frac{1}{4}$ in. square, and this portion has been bent *cold* into a ring about 4 in. in diameter; while the other end of the sample has been split up for about 6 in., and then welded perfectly.

We may now speak briefly of some

tests, made by order of Rear-Admiral Dahlgren, at the Navy Yard, Washington, of some samples of steel manufactured by the Sherman process at the works of Messrs. Anderson and Woods, at Pittsburgh. These samples consisted of steel bars of various degrees of hardness manufactured partly from Juniata bloom ends; partly from ⅔ Juniata bloom ends, and ⅓ Peru, Missouri; and partly from ⅔ Peru and ⅓ Swedish iron. These samples gave tensile strengths varying from 95,747 lbs. to 140,056 lbs. per square inch, while the greatest elongation recorded (the elongation not being given in all cases in the official report before us) was 0.3 in. in a length of 5.04 in. A sample having a longitudinal flaw running through it, which had been made by melting down common scrap iron in a crucible, and drawing down the ingot to 1 in. square, broke with a strain of 68,501 lbs. per square inch, while a piece of steel saw blade made by Mr. Sherman's process, and evidently of extreme hardness, is recorded as having broken with a strain of 220,900 lbs. per square inch.

We have now laid before our readers the main facts in our possession concerning the Sherman process, and we prefer for the present to leave them without comment. We hope before long to be in possession of such analyses of pig iron treated, and of the products in the various stages of manufacture, as may enable us to speak with greater authority on the value of the process, and of its future prospects—good or bad, as they may be—than it would be possible for us to do at present; and all we can say here, therefore, is that we trust that Mr. Sherman may have a fair field for his trials, and that he may, before long, be enabled to lay before the public such complete data respecting his experiments as may at once enable iron and steel manufacturers to correctly estimate the value of his results.

BOILER EXPLOSIONS.

By R. WABNER.

Translated from "Der Berggeist."

The possibility that the cause of explosions may be due to explosive gases generated in flues of a boiler has escaped attention. That explosive compounds generally result from the burning of coal no person can doubt. Many a reader has had unpleasant proof that a common stove may be burst by too sudden and abundant coaling. Explosive mixtures easily form in the gas-stove now in general use in Upper Silesia. If the gas flowing from the generator into the large receiver of the stove is overheated and set on fire, a violent explosion follows.

In the same way explosive mixtures may form in the spaces under and near the boiler, which when set on fire must cause violent concussion in the walls, and also in the water and steam contained in it. If the steam-tension in the boiler is very high, and if besides this the walls from long use have lost their original elasticity and resistance, a sudden rupture occurs, or a compression of the walls; the latter a phenomenon not heretofore explained.

The cause of the formation and collection of explosive compounds in the fire and smoke passages is usually to be found in the hindering of the discharge of the fire-gases through the chimney. If, when the fire is at height and coal is just fed, the smoke damper is suddenly closed; or if a partial stoppage of the draft in the chimney is caused by a fall of soot or of the brickwork of the chimney, the consequence is a collection of smoke and unconsumed gases under the boiler; since in consequence of the great heat of the fuel the generation of gas still continues, even when the draft is stopped. The formation of flame also ceases. Atmospheric air rushes in through the doors and grate and mingles with the collected gases, so that the whole mass may be suddenly set on fire; a circumstance that may cause a momentary generation of heat, or a sudden expansion of gas, followed by a violent explosion.

Of course not every collection of gas and sudden firing are followed by an explosion of the boiler; this must also

depend upon a relatively high steam-tension, or a bad condition of the boiler plate.

In view of this explanation the smoke-damper must be considered as the possible occasion of an explosion. The partial closing of the damper must be especially dangerous, since a momentary collection of gases may result, and at the same time atmospheric air be drawn into the fire-chamber. The circumstances attending the frequent boiler explosions lately occurring in Kattowiz have led to this view of the cause ; and this has lately received confirmation from a case of explosion at Bochumer.

NOTES ON A PROCESS FOR THE PRESERVATION OF BUILDING-STONES.*

By A. H. CHURCH, M. A.

From "The Chemical News."

My attention was directed to the subject of the preservation of stone about 1860. In 1862 I took out a patent for this purpose. The process consisted in the alternate application of solutions of pure baryta and pure (dialysed) silica. The plan was partially successful, and possessed the great advantage of causing no discoloration or efflorescence on the stone. But the solutions were rather weak, and, therefore, many repetitions of the process were necessary to secure an effective protection. Then, too, the silica solution failed to penetrate calcareous stone to any appreciable depth, owing to its rapid coagulation. After some years of further experiment, improvements were devised which ultimately resulted in a new and much more successful process. This process, for which a patent was obtained, in 1869, by Ransome's Patent Stone Company, consisted in the successive and repeated application of three liquids. The first of these is a solution of mono-calcic phosphate, often erroneously termed biphosphate of lime, and first introduced, I believe, for a similar purpose, by Coignet. The second solution is one of barium-hydrate, applied warm if possible ; and the third is a dialysed solution of silica, to which small quantities of the ordinary potassium and sodium silicates of commerce have been subsequently added.

It will not be necessary to dwell upon the proper methods of applying these solutions, nor upon the details of their manufacture. I may, however, mention that there is no difficulty in obtaining the various solutions in a state of sufficient purity and strength, and at a sufficiently low rate, to admit of their economical employment for the purpose in view. And it may be interesting to state that the dialysers employed, which are of the capacity of 6 gallons or more, and of an open bell shape, are found capable of doing their work very successfully when floated on or suspended in barrels of rain water, or on rafts in a tank or pond ; the movement of water below the diaphragm or vegetable parchment increases remarkably the rate of separation.

The reactions which take place between the several solutions themselves, and between the solution and the constituents of the objects treated, cannot be described in detail. The mono-calcic phosphate becomes chiefly di-calcic phosphate in contact with a limestone, and then, on the application of baryta, a barium di-calcic phosphate is formed. If decay has already taken place, and sulphates have been formed in the stone, these are converted into insoluble and non-efflorescent barium sulphate, while the lime and magnesia thus liberated immediately become phosphated by the subsequent application of the mono-calcic phosphate solution. The siliceous solution finally employed keeps good some time, and penetrates some distance beneath the surface. It contains, indeed, a small quantity of alkalies, but their amount is not sufficient to produce any soluble salts in the treated stone or bricks. It would be tedious to enter into the proofs of this statement furnished by direct experiment. Extensive trials of the new process have been

* Read before the British Association, Liverpool Meeting, Section B.

made on many important buildings, some of which have been entirely treated by the three solutions described above. I may cite as examples of the use of the process, the Chapter House at Westminster, and the St. Pancras Midland Terminus; portions of Canterbury Cathedral have also been submitted to treatment, together with numerous other buildings, public and private. Where the direction has been carried out with fidelity the results have invariably promised well. No marked alteration of the appearance of the stone is to be seen after the lapse of a few months from the time of using the process. The waterproofing of the stone effected by the use of the solutions is seen in many ways, particularly when after a shower of rain the color of the treated surfaces is seen not to be darkened by absorption of water. A piece of black cloth drawn over a piece of Bath or Caen stone after treatment neither blackens the stone nor is itself whitened by it.

I may add, in concluding this very imperfect notice, that my process is one of those just selected (1870) for the renewed trial at the Houses of Parliament. The specimens exhibited are treated and untreated specimens of the chief stones employed at the Chapter House, Westminster, and at the St. Pancras Terminus.

THE RECENT TORPEDO EXPERIMENTS.

From "The Mechanics' Magazine."

The torpedo question has recently advanced another step towards practical solution, a series of important experiments having taken place at Sheerness and Chatham during the past and previous weeks. These experiments were briefly noticed by us in our last number, when we promised further details both of the torpedoes and of the experiments, and which we now supply. These experiments were made with both moving and fixed torpedoes, the former being tried at Sheerness, and the latter at Chatham, in the presence of the Commander-in-Chief. Taking these experiments in their proper order we will first notice those made at Sheerness with what is known as the fish-torpedo. A few words respecting the history of this apparatus will not be out of place here. Towards the close of last year the scientific world was startled by the announcement that a torpedo of wonderful construction, and possessing still more wonderful powers of offence, was being tried on behalf of the Austrian Government. The stranger hailed from the little port of Fiume, where it might be seen under the strictest surveillance of its inventor, disporting itself in the briny waters of the Adriatic. It was in shape like a fish, and could be made to travel in any direction under water, being self-propelled and capable of moving at an upward or a downward angle in a straight horizontal line or in circles. A general description of this fish-torpedo appeared in the "Mechanics' Magazine" for December 19, 1869, since which time it has found its way into British waters, and was made the subject of experiment by our own Government on Saturday week in the estuary of the Medway. A profound mystery has been made to surround this fish-torpedo, its construction having been carried on at Chatham with the utmost secrecy. We, however, know somewhat of the weapon from our acquaintance with its performances at Fiume, and although its details may since have been slightly modified, yet its general principles remain the same. So by the light of our previous knowledge, and the slight additions that have recently been made to it, we shall be able to give our readers a tolerably clear notion of this new wonder of the deep.

The conception of this torpedo is due to Captain Luppis, a retired officer of the Austrian navy, but the credit of its practical realization belongs to Mr. Robert Whitehead, an English engineer residing at Fiume. Captain Luppis suggested a floating and travelling torpedo, the fore part of which should be filled with an explosive material, the after portion being occupied by the propelling power, which was to be steam. The practical mind of Mr. Whitehead at once saw that this was an altogether impracticable arrangement, and he at once set to work to design a torpedo according to his own notions of what such a weapon ought to be. He gave it a form approximating to that of

the sword-fish, but besides the projecting snout he added a vertical and two lateral projections, which are neither more nor less than triggers, and any one of which impinging upon an object with sufficient force fires the explosive compound, which is placed in the head of the fish-like structure. The body forms the engine-room and the storehouse for the propelling power, which is compressed air, and which works an internal engine by which an external four-bladed screw is actuated. Thus equipped the fish-torpedo is stated to be capable of a speed of from four to eight miles an hour, the average being four. It is fitted with fins for the purpose of guiding it through a tube attached to the torpedo ship, from which it is discharged into the sea for action. We thus have a submarine, self-propelling torpedo, a great improvement upon the crude notion of Captain Luppis.

Upon the occasion of the recent experiments, the "Oberon" was used as the torpedo vessel, having been specially prepared for that purpose. To this end the "Oberon" has been fitted with a tube 2 ft. in diameter, and about 28 ft. in length, which is situated in a line with her keel and some distance below her draught line. This tube is closed externally by a cap, and is divided internally into two portions, each being rendered water-tight by means of pinstocks, which also prevent the admission of water into the ship. The torpedo is passed into the rear portion of the tube upon rollers, and the pinstock behind it being secured, the one in front is opened, and the cap being removed from the orifice, the torpedo is expelled from the tube by a piston arrangement. The fins act as guides, bearing against four rails which are placed at the top and bottom of the tube. As the torpedo passes out of the tube a trigger catches against a s ud in the latter and starts the propelling machinery. As the tube is carried out from the stem of the ship in perfect line with her longitudinal axis, the direction of the submarine course of the weapon is exactly that of the direction of the ship, aim being taken by steering. The "Oberon" is fitted with a set of powerful air-pumps, which are worked by a 12-horse engine, and by which the air with which the torpedo is charged is pumped into it to a pressure, it is stated, of 40 atmospheres, or 600 lbs. per sq. in.

The object of attack on Saturday week was the hulk of the "Aigle," which lies in Sheerness harbor and has long been used as a coal store there. The "Aigle" is about 120 ft. in length and about 30 ft. beam ; she was moored fast at stem and stern with her head to sea, about a quarter of a mile from the fore shore of the Isle of Grain. The "Oberon" steamed out towards the "Aigle" the only visitors permitted on board being Captain Arthur, R. N., Captain Singer, R. N., and Lieutenant Wilson, R. N., the official committee appointed by the Admiralty to investigate and report upon the new weapon. The signal to prepare was made by flag on board the "Oberon" at 1h. 11m., the cap covering the discharging tube being raised twenty seconds later, the ship still steaming straight on to the target. She kept on her course until 1h. 13m. 35s., when she commenced backing hard astern, and was finally brought to a stand at a point apparently about 120 yards from the broadside of the "Aigle"—certainly not more than 150 yards. At 1h. 14m. the flag of the "Oberon" was dipped as a signal that the torpedo had been liberated, and in about 25 seconds a lofty cloud of white foam mixed with coal dust rendered it apparent that the torpedo had exploded against the hulk. The "Aigle" instantly dropped by the stern and her bows quickly came down to the same level, and at 1h. 16m. she was aground from end to end, having been moored in shallow water for the purpose of allowing the results of the explosion upon the vessel to be noted. The effects of the torpedo upon the hulk were very striking, as, indeed, they ought to have been, seeing that the weapon contained a charge of 67 lbs. of gun-cotton, and that the timbers of the "Aigle" were tolerably rotten. An examination of the wreck at low water showed that the starboard side was altogether cleared out for a length of over 26 ft. and a depth of about 10 ft. Half of the main deck was carried away and the remainder broken up, the planking of the upper deck having been started. On the port side of the hull the planking was blown outwards over an area 16 ft. long by 2 ft. deep. In short, the disruptive power of the charge was fully utilized, although we can in no way compare these results with those which would accrue to an iron-built armor-plated ship.

A subsequent experiment was made with a smaller torpedo, discharged from a gig 20 ft. in length, and at about the same distance from the hulk as the previous one. The second torpedo measured 14 ft. long and was 14 in. in diameter, its charge being 18 lbs. of glyoxaline. The discharging arrangement below the boat consists of a line of rollers carried by iron stanchions passing down from each side and meeting beneath. And here we may observe that previously to the first experiment a length of 60 ft. of netting was placed outside the "Aigle," about 5 yards from her broadside—it was made of $\frac{3}{4}$ in. rope, and had 4 in. meshes. The object of this net was to test its efficiency as a protection for a vessel and at the same time to indicate whether at such a distance away the explosion would have any effect upon the hull of the ship. All being ready the torpedo was started on its way, being directed against the netting, in which it was caught, and exploded. Notwithstanding the heavy charge in the torpedo no damage whatever was done by it to the hulk, nor, so far as could be ascertained at the time, to the netting either; so that it was only demonstrated that the torpedo could be caught and would be exploded by such a contrivance.

So far as these bare experiments went the results proved eminently successful, but to our mind there are other requirements which go to make a perfect torpedo, and which are evidently not embodied in Mr. Whitehead's invention. The fish-torpedo undoubtedly does credit to Mr. Whitehead's ingenuity when we consider its ability to move in any direction and at any depth in the water. But it requires many experiments to show whether under the varying conditions of calm and wind, light and darkness, the torpedo can be invariably relied upon for correctness of aim and the distance determined at which it can effectually be run against a vessel. No doubt it was an easy matter to steer the "Oberon" direct on to the broadside of the "Aigle," and to plant a torpedo upon her at a distance of 150 yards only, in the comparatively calm waters of the Medway. If, as the inventor asserts, the torpedo can be run at ships at ranges of from 600 to 700 yards, why was so short a range as 150 yards necessary, except to make sure of the aim and of the explosion of the torpedo, which everybody knew must explode upon contact? If we take winds and waves, tide and currents, weather, and the exigencies of warfare into account, we shall probably find a vessel anchored half a mile off from a torpedo ship to be a tolerably safe place, and a vessel moving at the same distance very much safer. If a steamer has to be run within 150 yards, as the "Oberon" had, and to back and fill and to be brought to a dead stand before delivering her torpedo, we think she stands a very good chance of being disabled by the guns of the enemy before she can complete her mission. What is wanted in a moving torpedo is that it can be guided with certainty towards an object, can be advanced or withdrawn as may be needed, that it can be rendered fatal to a foe and innocuous to a friend, and, above all, that it can be directed unerringly at ranges relatively safe with regard to the position of the enemy's ships. Such a torpedo we believe the fish-torpedo not to be, but the details of such a one we hope shortly to place before our readers.

There is yet another element which has to be taken into account in considering the subject of moving torpedoes, and that is the question of cost. And we are the more induced to look at the matter from this stand-point, because the fish-torpedo appears to be an exceptionally expensive apparatus. The cost of acquiring the right to use it will undoubtedly be something considerable, if proportionate to the prices paid by other countries. When it was first submitted to the Austrian Government, £56,000 was bid for the sole right to its use, the terms eventually being £20,000 for the right to use it in common with other States. The French Government subsequently wished to join with Austria in a monopoly of the weapon, but this proposition was not acceded to—unwisely, we think—by Mr. Whitehead. There can be no doubt but that the English Government will have to pay a stiff price if they want the fish-torpedo. But we might overlook an extravagant price for the right of use, if it were justified by the purchase, which to our mind it is not at present. The expense of manufacture of the fish-torpedoes, too, will be very considerable, the smallest fry costing £200 each. These, moreover, appear to stand their only chance of hitting a ship when well within 200 yards range; what,

then, are the chances of a larger one hitting the mark at 1,000 or 1,500 yards? And then there is the further expense of altering vessels for discharging them from, or of putting torpedo tubes in our men-of-war, as has been suggested, but which alternative we certainly deprecate for many reasons. The very character of the fish-torpedo is impressed with the stamp of costliness; its mechanism is liable to get out of order, necessitating special workmen on each torpedo ship to attend to their use and repair. We give—as, indeed, we have already done—every credit to Mr. Whitehead for his ingenuity, but we cannot give him much hope for the success of his invention as a torpedo to be used out at sea, and for coast and harbor defence we have others better suited to the purpose. For sea purposes, we have not yet seen anything superior to the Harvey torpedo, with which our readers are well acquainted through our columns. This apparatus has proved itself effective in all seas and all weathers, whilst we doubt the efficiency of the fish-torpedo in still water at even moderate ranges, and deny its reliability in a rough sea, and at the ranges required in active service.

The experiments at Chatham were made with stationary torpedoes, and determined some interesting points.

RUSSIAN RAILWAY BRIDGES.

From "Engineering."

Great activity is now displayed, as all the world knows, in the construction of railways in Russia. Upon the whole, the Empire of the Czars does not offer very grave obstacles to the railway engineer, unless, indeed, we except the passage of rivers and navigable streams. These present themselves in considerable numbers; and, as the Russian Government no longer permits wooden bridges to be built, a vast field is being opened for the construction of iron ones. During the last four years iron bridge work has been imported into Russia to the extent of 9,000 tons per annum, while similar iron work has been made in Russia itself during the same period to the extent of 3,000 tons annually. Including the cost of erection, the average outlay upon each ton of bridge work is estimated at nearly £22 10s., so that a very large capital has been and is still being absorbed by the construction of railway bridges in Russia. The Russian Government levies a heavy import duty on iron bridge work imported into its dominions. On the other hand, Russian mechanical establishments are allowed to import raw materials free of duty, the object of the Russian authorities being to encourage by all possible means the development of mechanical industry upon the Russian soil.

The Nicolai or Moscow and St. Petersburg Railway was recently incorporated in the important system known as the Great Russian. One result of the amalgamation has been the overhauling of the way and works of the Nicolai, which are found to stand in some need of repair. The wooden bridges which occur upon the line are also to be replaced by iron ones, the aggregate weight of which is estimated at 12,000 tons. The new bridges will not be made available without considerable difficulties, as they will have to be erected without any interruption of the current working of the line irrespective of great inherent constructive obstacles. Thus a new bridge to be thrown over the Msta (in the room of one destroyed about a year since by fire) will be 140 ft. above the level of the waterway, and its erection must be a very laborious undertaking. Then comes a great bridge over the Neva at St. Petersburg This work, after having been the object for twelve years past of all kinds of discussions and deliberations, is at last about to be undertaken. If the most recently approved plan is adhered to, this bridge will be something over 1,100 yards in length, and it will rest on twelve or fourteen piers. Its weight may probably be estimated at 6,000 tons.

Contracts are about to be let for bridges on the Smolensk and Brest, and the Woronesch and Rostow lines; the total weight of these bridges is estimated at 5,800 tons. The Woronesch and Rostow line is to be extended eventually to the Caucasus, and a great bridge will in that case have to be thrown over the Don near

Rostow, while several other important works will also have to be executed. Bridges of the estimated aggregate weight of 900 tons occur on the Brest and Grajewo line. A great bridge to be thrown over the Dnieper, near Krementschug, will weigh 3,000 tons. Irrespective of the few bridges thus specially enumerated, it is expected that Russia will establish during the next three years 2,000 versts of railway per annum ; and assuming that 7 tons of bridge work will occur per verst upon these new lines, these works will alone involve 14,000 tons. Upon the whole, it seems clear that for the next three years at least upwards of 20,000 tons of iron bridge work will be annually executed in Russia.

Although the Russian Government is doing its utmost to stimulate Russian industry in every form, it seems extremely doubtful whether Russian mechanical firms will be able, after all, to meet to a greater extent than one-half the demand which will probably arise in Russia for iron railway bridges. Messrs. Struwe Brothers, of Kalomna, contractors for the great Kiew Bridge, whose tools enable them to construct bridges of the largest dimensions, and who have acquired in consequence an eminent position in Russia, cannot produce more than 3,500 tons per annum with their present appliances. The establishments of Messrs. Politika and Semianikoff, at Alexandrowsk, near St. Petersburg, come next in order. These works have been conducted since November, 1869, by a company directed by M. Basson, formerly engineer-in-chief on the Warsaw and Vienna Railway. The works undertook recently the establishment of the Kowroff Bridge on the Nischnei line ; they are pretty well organized, and under their present energetic direction they may, perhaps, turn out 3,000 tons of work annually. Then comes the establishment of Messrs. Lilpopp and Rau, near Warsaw. These works, which recently completed a great railway bridge near Brest, and which are charged besides with the establishment of a bridge near Tiraspol, as well as with the execution of a great part of the bridges on the Moscow and Smolensk Railway—are also in a position to supply about 3,000 tons of work annually. The Bernadaki works, belonging to Prince Tenischeff, at St. Petersburg, might also furnish about 1,500 tons ; but if we combine all these four totals together, we still arrive at an annual aggregate of only 11,000 tons.

There would still seem, then, to be considerable scope for foreign industry in Russia in the matter of iron railway bridge building. According to official data, the railway bridges imported into Russia during the last three years have come from neighboring countries in the following proportions : France, 41 per cent.; Belgium, 30½ per cent.; England, 20⅜ per cent.; and Germany 8⅛ per cent. French and Belgian bridge builders enjoy a considerable reputation in Russia, and thus have borne off the largest share of this description of work which Russia has given out to foreign countries. On the other hand, Germany stands better in Russia than either France or Belgium in the matter of locomotive and carriage building. Such are a few details with regard to Russian railway bridges. The railway will achieve a social and commercial revolution in Russia ; and the railway, as has been shown, is dependent to a great extent upon large iron bridges. It seems clear, then, that for some time to come Russia will prove a valuable field for this department of mechanical industry.

Artesian Well in Nebraska.—The labors of the parties who had been boring for the last eighteen months in Lincoln, the capital city of Nebraska, for salt water, were crowned with success. At the depth of 600 ft. below the surface, in a stratum of sandstone, a lead of the great subterranean sea of salt water was recently struck, and the briny torrent came struggling up around the auger and shot into the air some 8 or 10 ft. It has since flowed strongly and steadily, and with great force and increasing strength, forming a briny rivulet. It is believed by the experts who have seen the flow, that when the auger is withdrawn and tubing inserted, a stream of water will be projected from the well to a height of 50 ft., making it the most magnificent artesian well of salt water in the world.—*Nonpareil.*

The average rain-fall at New York city is 49 inches. It is usually called 44 inches.

THE ARCHITECTURAL TREATMENT OF BRICKWORK.

From "The Building News."

When Charles the Second decreed that the rebuilding of London should take place in materials not liable to be destroyed by fire, he did not possibly contemplate the changes he would bring about in the architectural character of his metropolis. The mediæval wooden buildings, and the quaint half-timbered houses which had been erected under the Elizabethan revival of Classic architecture, had now at once to be replaced by structures in brick or stone. And, thanks to the fire, we lost by a stroke of the pen the picturesqeness which seems to have been peculiar to our wooden architecture, and our forefathers were constrained to adopt novel methods of building in fire-proof materials. If we can imagine a body with such authority nowadays as the Metropolitan Board of Works determining, say from January 1, 1871, that no buildings in brick or stone should be commenced in London, we can conceive what an impulse would be given to iron and timber construction; and in 1666, with an entire city of 13,000 houses to rebuild, the demand for architects in these new materials must have been enormous. But the law which teaches us that with the demand must come the supply, held good after the Fire of London, and it soon became evident that the new London was to be a brick city. Indeed, it could hardly have been otherwise; the means of transporting stone were few and limited, and good building stone is nowhere found in the immediate vicinity of the metropolis. Moreover, there was no time to be lost; the chroniclers of that day, Evelyn and Pepys, describe the wretched straits to which the unfortunate citizens were reduced, camping about in tents in all the open spaces round London, and huddled together in the public buildings which had escaped destruction. They did not then doubtless pay much attention to the architecture or to the exterior of their houses, and the revival which was such wonders in Italy played a very small part in the rebuilding of London. Of course, with the masterpieces of Wren and Inigo Jones before us, the Renaissance cannot be said to have been entirely neglected in this country, but, with the exception of the churches and a few of the mansions of the nobility, Classic tradition, at the very period of all others when it had its most important chance, failed miserably to make an impression upon our street architecture. The reasons for this failure will have to be sought for probably in the materials, for it seems an unquestionable fact that the massiveness and grandeur of Classic architecture cannot be translated into brickwork; it essentially requires a stone treatment—or shall we say a stucco one? Luckily that vile sham was then unknown, and we were saved a stucco rival of Rome or Florence, for there is no knowing what Wren might have been called upon to do had Parker or Austin flourished in 1666.

The real cause of the adoption of the "brick-wall-with-holes-in-it" style in London was of course that this was the simplest and cheapest way of sticking square bricks together, and even if we had had designers and manufacturers who could have furnished our citizens with the rich and varied terra-cottas which were then in use in Northern Italy, we question if their wares would have commanded any sale. But it is of no use speculating what might have been the case; we only know what did happen, and we can but regret that for nearly 150 years our street architecture remained devoid of every characteristic. The age which produced Kensington Palace, Marlborough House, and Great Queen street was only better than that which gave us Gower street and Mayfair in that the bricks were better made, and red instead of grey, as the color is now called—dingy black would be a fairer term to express the hue of modern brick-work. The red color of the eighteenth century bricks was due, as is well known, to their being burnt with wood in close kilns, instead of in clamps with breeze as is now practised. The nineteenth century was heralded in with the discovery of stucco, and stucco has probably wrought almost as important a change in the aspect of London as did the Great Fire. To stucco we may attribute all the evils to which architecture is liable. These may be briefly described as bad designs, bad materials and bad construction, and the only comfort in contemplating

a row of stuccoed houses lies in the fact that they are so deficient in durability that few, if any, of them will outlast the ninety-nine years of their leases. The introduction of stucco may, in fact, be regarded as the commencement of the third epoch of London street architecture; and as the masterpieces of stucco, we cannot do better than refer to the works of Nash, who was its High Priest. In Regent street, which still not unjustly claims to be the finest street in London, we see, or rather we don't see, brickwork revelling in Classic attire, and the terraces overlooking Regent's Park are well-known examples of the transforming power of Parker's cement, as it was at first called. In spite of all our progress in other matters, we are still sticking in the cement period of our architecture, and we can only anticipate by contrast with our contempt of the plain brick-wall treatment (which still, by the way, drags on a lingering existence in remote suburbs) what will be the feelings of the architects of the next generation when they reflect upon our protracted thraldom to this disgraceful sham. With all the grand new squares at South Kensington to build,—for with the vast extension of London northwards and westwards we still go on in the old jog trot routine of stucco squares and stuccoed semi-detached villas--may we indeed dare to hail the Grosvenor mansions as a sign of better times coming as a dove of promise, as an indication that the nobility and gentry will dare to enshrine themselves behind any other material than stucco? We hope so! We verily will try to persuade ourselves and our readers, that after 70 years of pseudo Classic civilization, we are going to return to something genuine again, and to allow what we have for some time been showing inside our churches to be seen outside our houses—namely, plain honest brick. If it were not for very joy, we should be tempted to find many faults with the Westminster improvements, and there are to our mind many forms of brickwork better adapted to our street architecture than the pretentious buildings springing up on the outskirts of Belgravia. But we must be contented with small mercies and hope for better times in the future. At the Kensington Museum, and latterly at the Royal Albert Hall, we get entirely another plan of dealing with brickwork, and the attempt to decorate brick buildings solely with terra-cotta constitutes to our mind the dawn of a fourth period in London architecture. If our readers smile at our selection of a few isolated buildings as the nucleus of a style which is to influence the entire architecture of our metropolis, we can but remind them of the insensible way in which this very South Kensington influence has gradually become apparent throughout the country. If in matters of art education we are compelled to admit that we have derived assistance from the existence of the Department of Science and Art, why should we scruple to learn what we can in matters of architecture from the band of art students and art workmen who have received their training at the hands of this institution? But while South Kensington must be allowed to have led the way to the successful employment of terra-cotta, we can also point to the works of Mr. Barry, who has demonstrated in the most satisfactory manner at Dulwich College that this material can be employed with effect; and there are if we cared to enumerate them, other buildngs, which testify to the growing appreciation of this material for building.

Now when we undertook to write upon the treatment of brickwork, we had in view the possibility of choosing either one or the other of the following alternatives —either, firstly, to consider brick (which, as we have shown, is of necessity the building material *par excellence* of London) in the light of a mere constructive necessity, and to demonstrate that although we cannot avoid it, we may contrive to veil it from the eye by means of some decorative sham, such as ashlaring or stucco; or, secondly, to look upon brick as a true building material, which should be so considered in the design and so disposed in the building, as to tell as brickwork, and as such to form a part of the architecture. We have shown the reasons for the adoption of brickwork in London, and we have pointed out that brick, and brick alone, was employed for the majority of our buildings during 150 years. We have seen that when stucco was invented, our architecture was so modified that the natural material, brick, was contrained to retreat behind a hideous veil of that wretched sham, through which, however, its constant tendency is, and ever has

been, to show its familiar face, disfigured and deformed by all the unsightliness which bad material and bad workmanship can achieve. And now, in conclusion, we would hail with joy the movement we think we can see the signs of, and which we firmly believe will soon be very apparent, in favor of again employing plain honest brickwork for the façades of our houses and public buildings. We have endeavored to prove that the reason for the ugliness of London is the want of a style of architecture suited to the material, and capable of dealing with the sizes, forms, and color of bricks. After two centuries wasted in hopeless struggles after this style, we believe that neither in Gothic nor in Classic art can these exact requirements be fulfilled, but that to build truly in London we must begin with a brick $9 \times 4\frac{1}{2} \times 3$, and on this form such modifications of the received traditions of order and proportion as are capable of being executed in the materials with which we are dealing. Every one will readily admit that this is the common sense method of treating brickwork, and for the purposes of enrichment, bricks in the form of terra-cotta may receive any amount of decoration. In the best period of all architecture we find the enrichments wrought in the same materials as the remainder of the building, marble for marble, stone for stone, terra-cotta for bricks.

With this appeal to precedent we will leave our readers to form their own opinions upon the correctness of the principles involved in the revival of brick architecture which is now taking place in London, and we can only hope that the conclusions at which we have arrived will be justified by the future of London architecture, and that we may at no distant period revert with satisfaction to the views we have now expounded.

THE DIAMOND FIELDS OF SOUTH AFRICA.

By HENRY HALL, F.R.G.S.

From "The Mining Journal."

North and north-east of the Cape Colony exist vast rolling plains forming a plateau, or table land, of an average height of 4,000 feet above the sea, studded over with innumerable detached kopjies, pointed or flat-topped hills of moderate elevation (spitz-kopjies or tafelbergen), which gradually decrease as we approach the Vaal River, of basaltic or green porphyritic rock protuded as it were through the more recent sandstone or conglomerates of the lacustrine formation, which cover the whole region in almost horizontal layers. These plains are fringed round from the north-east to the south-east, an extent of many hundred miles, by high and, on one side, precipitous mountain ranges. The Plombergen, Maluti, Quathlamba, Drachenberg, and Magaliesbergen, varying in height from 5,000 to 10,000 ft., which, forming the watershed of two different branches of the Gariep or Orange River and its tributaries, the Vaal, Caledon, Hart and Modder rivers, rise in escarped faces on the coast side like gigantic buttresses supporting these lofty plains, and separating them from the lower terraces of the Cape Colony, Kaffaria, Natal, and Zululand. It is not more than half a century ago since these regions attracted the attention of the Cape colonists, first as the scene of the murderous forays of the Zulu tyrants, Chaka, Moselikatze, and Dingaan, whose warriors almost extirpated the more peaceable Betjimana tribes who inhabited the land, and the remnant of whom, forming the Abasutu tribes of Mocheshi, took refuge in the inaccessible valleys of the Maluti mountains, where they still preserve their independence; and more recently as a vast hunting field, first described by Captain Harris, in 1836, as teeming with elephants, rhinoceri, giraffes, and all the larger species of antelopes—the former quite, the latter nearly extirpated.

Then, in a political point of view, came the exodus of the Cape Boers from that colony, and their settlement on the Orange River plains and Natal; the wars consequent thereon; the final withdrawal of the British rule, which, in the first instance, had been extended to this region; and the establishment of the two South African Republics, the one north of the Vaal River called the Trans-Vaal, and the

other in the region between the Vaal and Cape frontier, which in that direction is the Gariep or Orange River, called the Orange River Free State. Two listless communities, devoid of any seaboard or port, with the inhabitants leading a life without excitement, vegetating rather than living on the vast extent of monstrous treeless plains of 10,000 or 15,000 acres each, called "places" or farms, although in Europe they would be called estates; wandering about with their sheep and cattle from one green spot of pasture to another, being much in the style of the ancient Patriarchs, in a very similar region between Palestine and the Euphrates; while the customs dues on all the articles of foreign produce they consume go to swell the exchequer of the British colonies of the Cape and Natal, in whose harbors they are landed.

Events, however, have been lately occurring on these plains, and along the banks of the many rivers, or rather watercourses, which intersect them, and which run but for a few months of the year, but which, after heavy rains or thunderstorms along the tempest-riven peaks of the Drachenberg and Maluti ranges, pour down perfect avalanches of debris, composed of gravel, pebbles, and other alluvial deposits into the turbid waters of the Vaal or Yellow River, the Modder or Muddy River, and the Gariep, Orange or Great Black River, and which in the dry season, when the soluble matter has been washed away and deposited in the shape of mud on the banks, exhibits, on the shoals and shallows of the stream, beds of pebbles containing agates, camelians, jaspers, in great variety, and well-known to collectors of mineralogical specimens at the Cape as "Orange River pebbles." These pebbles are often curious and beautiful, and contain many rare specimens if examined by an expert; but they are too numerous to be deemed of any value, and are principally regarded fit for chimney ornaments, card-counters, and such trivial purposes, and few go to the expense of preparing them under the hands of a lapidary, so as to properly develop the beauties they really possess. As early as 1819 the missionary Campbell, who first explored the course of the Orange River, from its junction with the Vaal, in lat. 29° 20′ S., and lon. 23° 30′ E., to its embouchure on the west coast, describes a portion of the region he passed through as covered with pure crystal pebbles, sparkling in the distance like diamonds, and many other travellers mentioned the agates, jaspers, camelians, of the Orange River countries, supposing them to be the products of the disentegrating peaks of the surrounding mountain ranges.

The geology of South Africa rests on such imperfect data, and the extent of the penetration of basaltic or porphyritic rocks is so roughly defined, that we can here give but an imperfect theory of the region in which the diamond discoveries have taken place. These plains, it is supposed, have been formerly the bed of a vast freshwater sea or lake. Many miles down the Orange River, towards the ocean, violent volcanic action has, at a remote period taken place, forming the great falls of "Aukrubies," 150 ft. in height, and so creating an outlet for the inland waters. Denudations seem, consequently, to have occurred to a great extent, and various little kopjies or hillocks of diluvial matter, composed of quartz, agate pebbles, jaspers, and appearing as if deposited by eddies or whirlpools, occur on both sides and in the neighborhood of the watercourses; and on these little hills the clearest testimony shows diamonds have been recently discovered, in conjunction with conglomerate masses, cemented together with oxide of iron, tufaceous limestone, and other similar rock-forming substances.

The writer of this article lived for many years in South Africa, and is familiar with the localities in which diamonds have been found; but he never recollects a hint being given during that period that such treasurers really existed, although he has heard of, and seen, small rubies, sapphires, and amethysts, but of such a size as to be nearly valueless. It is now four years ago since the first diamond was discovered and sent to Cape Town. There is a few miles south of the Orange River near the northern boundary of the Cape Colony, and about 600 miles north-east of Cape Town, an obscure village, or seat of magistracy, called Hope Town, where the seat of the local government for an extensive tract of a thinly inhabited country being fixed, a church being founded, and possessing good water advantages, a cluster of houses, shops, and stores, for the supply

of the neighboring farms, sprung up, and from this Hope Town the first rumor of the diamond-bearing region along the banks of the Vaal and Orange rivers reached the ears of the commercial community at Port Elizabeth and Cape Town. A very fine diamond of the first water, valued at £500, fell into the hands of a trader there, who purchased it for a trifle from a native, amongst whose children it had passed for a plaything, paying for it, we imagine, a few sheep, cattle, or a wagon, which to a native is a fortune in itself. Many more of these shining stones (even uncut diamonds shine amongst their quartz companions) by degrees found their way into the hands of the little Hope Town winklers, as retail dealers are called in the Cape patois.

These discoveries were hinted abroad, and at last reached the ears of a celebrated firm of London diamond merchants, who sent a trusted agent out to make inquiries. Like almost all European geologists who for the first time visit the lacustrine deposits of South Africa, he made a most egregious mistake, and declared the supposed find of diamonds must have been what is called in slang language a "plant" made by some land speculator who wanted to dispose of his farms, but that in a geological point of view, it was impossible that diamond beds could exist in that region. He might perhaps be strictly right, but he appears to have entirely overlooked the vast physical forces that carried and deposited them there. The same earth-throe that formed the Zambesi Falls of Livingstone, having probably at the same time made those of the Orange River, and draining the inland sea, covered the plains of the Vaal River with the diamond debris of the disentegrated peaks of the Maluti mountains.

Time went on, the public were still incredulous, but by degrees one diamond, then half-a-dozen or more rough and uncut were offered for sale in the Port Elizabeth markets. The Governor, Sir P. Wodehouse, was known to have purchased several, and the house of Mosenthal & Co., a Cape commercial firm of repute, were reported also to have invested largely though quietly in the same speculation; but it was not until the close of the second year, 1868, that the colonial world was startled by the announcement that a diamond of pure water had been picked up weighing 83½ carats. There is some obscurity about where it was found and by whom, but it eventually came from the hands of the native finders and intermediate traffickers, into those of Messrs. Mosenthal, for a considerable sum; was deposited for some time in the hands of the Cape Government, and eventually sent to Europe in the spring of 1869, under the name of the Star of South Africa. It remained in London some time, was cut in Amsterdam, and although considerably reduced in weight, turned out a splendid brilliant, and was sold for a considerable sum—£14,000, we are informed, some say £24,000. After the discovery of the Star of South Africa, a regular *furore* sprung up for diamond digging, and thousands of the already sparse population of the Cape Colony and Free State are still flocking to the banks of the Vaal River, where, near the Mission Station Pniel on the south, and Hebron on the north side of the river, the principal finds have as yet been made of diamonds of all sizes, from 1 to 50 carats, besides a considerable quantity of the valuable, though inferior, diamond "Bort," used for cutting and polishing purposes. Although the appliances used are of the most make-shift nature, and the majority of the diggers totally inexperienced—few of them, probably, ever having seen a rough diamond before in their lives—within the last few months diamonds to the value of £100,000, very lowly estimated, have already been found, being an average of an earning of about 15s. a day for all those employed, now about 3,000; many of whom, however, have been as yet unsuccessful.

The romantic stories in the Cape papers, though not altogether devoid of truth, must, however, be taken *cum grano salis*. Many a digger may believe himself in possession of a real gem worth many thousand pounds which may turn out a worthless quartz pebble, while, on the other hand, in every shovelful of gravel hundreds of small diamonds, all of some value, may exist, and may be thrown aside, owing to the perfect inexperience of the "diamantzockers," as the Dutch boers call the diggers. In the meantime the value of landed property and produce of every kind in this once desolate region has marvellously increased. The Presi-

dent Pretorious, of the Trans-Vaal Republic, has laid down his baton of office, taken up pickaxe and shovel, and enrolled himself among the band of diggers, with all his officials with him. We find in the list of diamond seekers clergymen, medicos, Government clerks, and officials of high degree, farmers, officers of the army, two of whom, from Natal, it is said, have realized £15,000 in a few weeks. A sort of provisional government has been formed, and order and regularity exist to a wonderful degree; nor are the *agremens* of life altogether wanted, as we find at the diggings billiard tables, Christy minstrels, soda-water machines, etc.

We must not be surprised, however, to find many, both diamond seekers and buyers, disappointed, as in our judgment the prices said to be given for uncut diamonds at the diggings are far more than cut stones could be purchased for in London, Paris, or Amsterdam. Pniel and Hebron, where the principal explorations are going on, are stations of the Berlin Mission Society, near the great bend of the Vaal River. The missionaries very injudiciously levy a tribute on all diggers of 25 per cent. on the value of the diamonds they find, instead of demanding a moderate sum for a license for digging; this causes much concealment of diamonds found, on the digger's part. In a similar manner these worthies taxed heavily a few years ago parties seeking copper mines in Namaqualand, making the infliction worse by declaring it was for the "sake of the Lord." In the latter case it was also the Berlin or Rhenish Societies who profited, while their titles to the soil were in many cases anything but indisputable. The Pniel and Hebron diamond fields are about 800 miles from Cape Town, *via* Beaufort West, and 650 from Port Elizabeth, *via* Colesberg. The roads are in general good, and the use of bullock wagons enables parties of diggers to carry the necessary supplies with them, which on the spot would prove very expensive.

The following extracts from the correspondence of many respectable and trustworthy persons who have visited the diamond region may prove interesting. Mr. Cooper, of Cradock, writes to Dr. Grey, of the same place:—"The position in which the diamonds are found is a complete enigma to me. The richest find has been on the top of a 'kopjie,' perhaps 100 feet above the river. Indeed, the present run of the river has nothing to do with the find of the diamonds. The whole country must have been submerged, and the matrix in which the diamonds are found must have been deposited in the run of the inundation, current, lake, or body of water. The matrix is found upon and between the chinks of the rocks. The surface is strewn with fragments of rocks and metamorphic sandstone, I think pudding-stone, quartz, and also ironstone. I do not think any of these rocks are abrased by friction; their edges are more or less rounded off, but this arises, I think, from decomposition. Diamonds continue to be found daily; yesterday a 29½ carat, and the day before a 17½ carat, besides many smaller." Another correspondent says:—"In regard to the constituent stones of good diamondiferous gravel, satisfactory information cannot be got. Some diggers prefer a light-colored and sparkling gravel, others again are in favor of a dark-colored pebbly soil. Rotten ironstone or basalt pebbles are considered a favorable sign; gravel with quartz fragments, not water, more the contrary. For many reasons I am inclined to think the best indications are garnets (spinel rubies), and peridot, a blue transparent crystal."

Another writer, Mr. Gillfillan, late of the Royal School of Mines, in an interesting letter to the Editor of the "Grahamstown Journal," mentions:—"Undoubted diamonds deposited here (junction of Vaal and Modder rivers), conglomerate and yellow schist, pebbles of black and red jasper in highly ferruginous soil, stratification of rock horizontal. All the pebbles and crystals in this ferruginous soil are coated with a thin deposit of oxide of iron. I examined a stone in the possession of a Hottentot, about 3 carats, a rhombic dodecahedron; owner refused to sell. It was of first-rate water, but speckled and flawed; value about £30." As the diggings are developed, he will perhaps be able to add a second part to the present article, as it is highly probable, owing to the volcanic disturbances in the lower course of the Orange River, and the metalliferous region of Namaqualand traversed by it, that mineralogical discoveries will be made there which may turn out of the first importance.

NEW ELECTRO-DYNAMIC LAW.

By H. HIGHTON, M.A.

From "The Chemical News."

Will you allow me to announce in your journal a new and important electro-dynamic law or laws. The new reasonings and experiments by which they are supported, I hope to enter on more fully in the next number of the "Quarterly Journal of Science." Meanwhile, I submit them to the judgment of physicists for examination and approval, or otherwise.

1. In every galvanic circuit, the net heat produced by the chemical decomposition is divided into three parts—(*a*) due to merely local action arising from the impurities in the positive metal, or the reformation of water from the nascent hydrogen; or (*b*) that which circulates through the battery and all other parts of the circuit, and which varies as the electro-motive power of the negative element in relation to the electro-positive; and (*c*) the residue which remains in the battery.

2. That part which circulates through the whole circuit, is distributed in each part of the circuit, including the battery, in simple proportion to the resistance of each part.

These laws are thus expressed mathematically :—

Let H = total net heat produced;
H_1 = heat produced by waste local action on the positive metal;
H_2 = the quantity put into circulation;
H_3 = the residue not put into circulation.

Then, of course—

$$H = H_1 + H_2 + H_3;$$

and

$$\frac{H_2}{H_2 + H_3} = E,$$

E being the electro-motive force of the negative element in relation to the positive element used.

Also, if H (*b*) be the total heat evolved in the battery when the circuit is closed :

$$h(b) = H_{(1)} + H_{(3)} + H_2 \frac{R}{R + r}$$

$$h(c) = H_2 \frac{r}{R + r}$$

and if $r_{(1)}$, $r_{(2)}$, $r_{(3)}$, be the resistance of different parts of the circuit; and $h_{(1)}$, $h_{(2)}$, $h_{(3)}$, the heat evolved in those parts;

$$h_{(1)} = H_2 \frac{(r_1)}{R + r}$$

$$h_{(2)} = H_2 \frac{r_2}{R + r}$$

and so on. Again, if

$$H_{(3)} = 0 \text{ or } \frac{H_2}{H_{(2)} + H_{(3)}} = 1$$

then the electro-motive power of the negative element is perfect as relates to the electro-positive element.

In a circuit of zinc in sulphate of zinc, and copper in sulphate of copper, E = 1, or the whole heat produced is transmitted; with zinc, strong sulphuric acid, and platinum, E = about $\frac{5}{6}$, but varies with the strength of the acid; with iron in sulphate of iron, and copper in sulphate of copper, E = about $\frac{2}{3}$; with copper in nitrate of copper, and silver in nitrate of silver, E = about $\frac{3}{5}\frac{9}{2}$.

The total electro-motive force of a couple depends partly on the net heat evolved, partly on the proportion of it transmitted through the circuit. The former depends principally on the positive element, the latter on the negative element.

Some researches have recently been undertaken by Von Pettenkofer on the amount of evaporation which takes place from the foliage of plants. The experiments were made in the case of an oak tree, and extended over the whole period of its summer growth. He found the amount of evaporation to increase gradually from May to July, and then decrease till October. The number of leaves on the trees were estimated at 751,592, and the total amount of evaporation in the year at 539.16 cubic centimetres of water for the whole area of the leaves. The average amount of rain-fall for the same period is only 65 cubic centimetres; the amount of evaporation is thus 8½ times more than that of the rain-fall. The excess must be drawn up by the roots from a great depth; and thus trees prevent the gradual drying of a climate, by restoring to the air the moisture which would otherwise be carried off by drainage.

REGULATOR OF F. R. VAN SCHWIND.

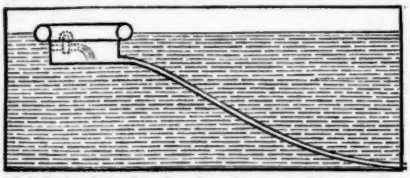
Translated from "Polytechnisches Journal."

In my experiments in the solubility of rock salt I required a running stream of water of exactly uniform discharge, and contrived the apparatus here described.

The reservoir consisted of a small box of wood, sheet-lead or copper. The dimensions were 20 cr. wide, 50 cr. long, 25 cr. deep, so that a sinking of 1 cr. gave a volume of 1,000 cubic cr. or 1 liber, and the contents and variation were indicated by a graduated glass tube.

Near the bottom of the vessel at one end is a small round orifice in which a tube 5 mill. in diameter is inserted water-tight, projecting within and without 1.5 *a* 2 cr.

The float consists of a rectangular frame, 11 × 4 cr., made of sheet-lead 2 cr. wide, soldered water-tight. Within this is a sunken box 11 cr. wide by 4 cr. deep, also soldered water-tight. At the middle of the vertical wall of this box a hole is bored, into which is inserted a fine tube of about 4 mill. bore, so that it lies within the float and can be handled from above. In the opposite side another opening is made close to the bottom, into



which is fitted a lead tube 5 mill. in diameter and 15 mill. long. A tube of gutta-percha 30 cr. long and 5 mill. in diameter connecting the discharging orifice of the reservoir with the tube of the float completes the apparatus.

If the reservoir is filled with water the float rises, and the water can flow into it only through the pipe into the float, from which it passes out of the reservoir through the gutta-percha tube.

The discharge is uniform until the float comes in contact with the bottom; for the depth of the centre of the pipe discharging into the float below, the free surface obviously remains constant as long as there is water enough in the reservoir to keep the float free from the bottom.

This apparatus can be used in feeding lamps, and, with greater dimensions, for supplying water wheels.

The longer the frame in the direction of the pipe, and the longer the pipe, the more constant the action of the apparatus; so that where great exactness is required the frame should be made as large as possible; the box and pipe to be set as far as may be from the orifice of discharge.

As a result of a lengthy series of experiments, M. E. Baudrimont concludes that tin-foil, in consequence of its impermeability for water, may serve with great effect to protect various substances from the effects of the atmospheric moisture, as well as act as a protective against the alterations fruit undergoes by evaporation of the fluids therein contained; tin-foil also protects against the oxidizing action of the oxygen of the atmosphere, and may hence serve to keep fatty substances from becoming rancid, while it may usefully serve in laboratories to wrap up caustic lime, bisulphite of soda, and similar substances, which may thus be preserved for a great length of time without deterioration.

Dr. W. Stein has devised an easily-executed process for the detection of madder colors upon cloth or by themselves. He boils the cloth with a concentrated solution of sulphate of alumina, whereby a liquid is obtained of reddish color, exhibiting a golden-greenish fluorescence, due to the presence of purpurine; the behavior of the coloring matters of madder towards sulphate of alumina is so characteristic that this salt may serve as an effective test for these substances; the alizarine may be readily rendered soluble by treating the dye material or dyed cloths with alcohol acidified with hydrochloric acid.

As a matter of scientific intelligence, we hear the Suez canal has passed into the hands of an English Company.

DRAFT IN CHIMNEYS.

Abstract, translated from the "Zeitschrift des Vereines Deutscher Ingenieure"

Meidinger of Carlsruhe, in an article published in the "Badischen Gewerbezeitung," 1867, p. 26, describes an apparatus illustrating the draft of chimneys. It consists of a tin tube bent at right angles, one leg vertical, the other horizontal. At the end of the horizontal portion a light is placed. The vertical tube (450 millim. long) is fitted below with a removable damper, while the upper end is made so that caps may be fitted to it. The horizontal leg is 240 millim. long; both portions have a clear diameter of 36 millim.

To prevent too great heating of the horizontal branch, it is surrounded with a closed envelope of tin 42 millim. in diameter, having in its upper end a small orifice, so that it can be filled with cold water. The vertical branch is also enclosed in an envelope of tin 54 millim. in diameter, which is intended for holding fluids.

To imitate the wind a double-acting bellows of moderate power is used. The air from this is carried through a long caoutchouc tube into a glass tube 300 millim long, drawn at the end to a diameter of 6 millim. By means of this, a stream of air can be sent into the upper portion of the apparatus from any required distance and from any direction.

The upright part of the apparatus represents the chimney, the horizontal portion the furnace, and the light at the end of the latter the fire on the grate.

The cause of draft in a chimney is the ascent of a current of air, which may cause an after-current of cold air through the furnace in two ways. Every moving body of air tends to cause a vacuum by making the air behind it rarer. In this way the external air is drawn into the furnace by the motion of the air in the chimney. This is neatly shown by the apparatus. If a light is placed before the horizontal tube the flame burns quietly in a vertical direction; but it is drawn immediately into the tube if a blast of air is blown upwards through the glass tube inserted from below into the upright branch. The flame keeps its horizontal direction as long as the blast is in action. That a draft is caused in locomotives in this way is well-known.

But in ordinary chimneys the operation just described is quite insignificant; in these the effect of heated air must be considered. The heat of the burning fuel expands the air and makes it lighter. The denser and colder air from without is forced in to restore the equilibrium, and passes out from the chimney with a temperature greater than that of the external air. It is therefore clear that the draft will be stronger, the greater the difference of temperature between the heat of the air within and that without the furnace. The draft and the combustion become very great after the fire has burned for a little while. This is also shown by the apparatus. For, when the flame has for some time been under the action of the blast, it continues to burn in a horizontal direction, if the bellows is removed and the cover is immediately applied to the lower end of the upright tube. But the flame resumes its upright direction if the tube remains open. This illustrates the bad effects upon draft of furnaces that have a common chimney when not heated and left open.

Draft increases with the height of the chimney as the square root of the height. This is only true of upright flues.

There is a well known distinction as to diameter between wide (German) and narrow (Russian) chimneys. The latter have a much stronger draft, because warm air fills them throughout, so that a rising of the whole column of air takes place; while in wide chimneys the cold air can enter from above, withdrawing much heat from the rising air and weakening the draft.

The material of the chimney-walls has an important influence upon draft, as the temperature of the column of enclosed atmosphere is dependent upon it. Iron chimneys by rapid cooling cause a weaker draft than those built of stone.

As soon as the temperature of the chimney-walls and the atmosphere within is higher than that of the external air there will be a rising current of air; and, on the other hand, there will be a backward current if the external air is warmer than that contained in the furnace. This is also neatly shown by the

apparatus. If the tube enclosing the upright leg is filled with warm water, the direction of the flame shows an upward draft; but if it is filled with a cold mixture of 7 oz. muriatic acid and 11 oz. Glauber's salt the flame moves outward showing a reverse draft.

Such a reverse draft often makes it very difficult to kindle a fire; the chimney must sometimes be heated by a quick fire of straw, paper, etc., in order to cause a rising current of atmosphere.

When the walls of a chimney retain a high temperature for a long time, an upward draft continues; this is even the case in dwellings that are not heated, as long as the temperature of the house is somewhat higher than that of the external air. If mild weather suddenly sets in, so that the temperature without rises, a reverse draft takes place and lasts until equilibrium is restored.

The apparatus illustrates the influence of wind upon draft very clearly; showing that it is not the chief hindrance of draft, and that it is often a help.

If a horizontal stream of air is blown over the apparatus at a height of about 10 millim., the flame is sucked in; the effect is greater if the stream is directed a little upward.

If the horizontal stream is directed so as to strike the tube a little below the end, a stronger draft upon the flame follows. The current is condensed and glides off the surface, causing a current that puts the column in the tube in motion.

If the horizontal stream is directed upon the opening, the blast-tube being applied to the edge of the chimney, the flame is blown away by a reverse draft. The reason is, the blast of air from the bellows-tube expands conically, setting in motion the adjacent layers of air, and with them the air in the chimney. This is forced backward by the stream consequent upon the concussion and condensation upon the walls.

The operation of the wind does not correspond to any of these cases, but rather to all combined. Natural wind can be imitated enough, if the end of the bellows-tube is held at a distance of 600 millim. and directed towards the upper end of the tube. Part of the conical stream in this case strikes the tube, while the upper portion passes over in a direction nearly horizontal. A lively draft is the consequence, showing that the wind draws the column after it. The current reflected from the tube and the horizontal current above form a resultant which is inclined above the chimney, but soon becomes a horizontal. An upward direction of the blast increases the draft as long as the angle toward the horizontal angle is not greater than 15 deg. The resultant then passes over the chimney in a horizontal direction. A larger angle causes a reverse draft. We see here why a person standing on a tower or bridge with a high balustrade is not struck by the prevailing wind, while he can feel with his hand the current coming upward against the wall below, and coming downward above his head.

The effect of chimney caps may be illustrated by the apparatus.

A collar or cornice is often put on chimneys as an architectural finish. Experiment with the apparatus shows, that these have an injurious effect. For this cornice catches the rising current, so that the horizontal wind alone acts and causes, as above shown, a back-draft. If there must be a collar, the chimney tube should rise above it at least 600 millim.

A horizontal plate set at some distance from the mouth of the chimney has a different effect.

Though this was at first used only as a protection against rain, it is the best means of preventing all injurious effects of wind. In experiments with the apparatus when provided with a plate, whatever may be the direction, and the force of the current of wind, the flame is drawn into the tube. The dimensions and position of the plate have an important influence. According to Meidinger's experiments, the plate should have a diameter double that of the chimney, and a light above its mouth equal to two thirds of the diameter. This contrivance makes it unnecessary to raise a chimney that opens under the peak of a gable roof.

A means has been lately devised in France, as protection against the wind, which has been applied in several chimneys at Carlsruhe. It consists of a cap of two plates crossing at right angles, pointed above, which are inserted into the chimney. The intention is, that two openings may remain open if the others are closed by the wind. The apparatus

shows that this does not happen, as in all cases wind is blown into the chimney.

Experiments with Wolperts & Noeggeratti's caps (described in the "Zeitschrift des Vereines," Bd. XIII. and XIV., gave favorable results.

THE ILLINOIS AND ST. LOUIS BRIDGE.*

THE WEST ABUTMENT.

The masonry of the west abutment has been completed from the bed-rock of the river to a point 31 ft. above low-water mark. From the bed-rock to the top of the masonry, the height is now 44 ft. Eight courses of granite are laid on it and two courses, or 5 ft. are required to complete it to the skew-backs against which the steel ribs of the western span will rest. This mass of solid masonry stands upon the lower edge of the wharf in St. Louis, and measures at its base, in the direction of the river current, 94 ft., and transversely 62 ft. 9 in., and contains at this time 6,380 cubic yards of masonry. When completed to the carriage-way, it will be 115 ft. high above the bed-rock of the river, and will then contain 11,860 cubic yards of masonry.

The work on it is going steadily forward in a satisfactory manner.

Although the bed-rock at the site of this abutment is 73½ ft. higher than at the east pier, the difficulties encountered in building its foundation were of a much more perplexing and tedious character than those encountered at either of the others. Its site had been for over 60 years a part of the steamboat wharf of the city, and, as such, had received every kind of useless material thrown overboard from the various steamers lying over it during that time. The old sheet-iron enveloping their furnaces, worn out grate-bars, old fire-bricks, parts of smoke-stacks, stone-coal cinders and clinker, and every manner of things entering into the construction of a Mississippi steamer, seemed to have found a resting place on this spot, and constituted a deposit averaging 12 ft. in depth over the rock. During the memorable fire of 1849, when 29 steamers were destroyed at the levee, the wrecks of 2 of them sunk upon the site of this abutment. One of these was partly covered by the hull of the other, which probably sunk immediately afterwards. The lower one was but 2 or 3 ft. above the bed-rock. After this terrible conflagration, the city authorities determined to widen the wharf. Its front was extended to a line inclosing about one-half of these two wrecks, by filling in with stone and rubbish from the city. During this extension, several other vessels were burnt at the wharf, and the wreck of one of these also sunk upon the site of the abutment. The coffer-dam, constructed to enclose the site, had to be put down through these three wrecks, the hulk of either of which was not probably less than 400 tons measurement. Their bottom planking was all of oak, 3 or 4 in. in thickness. To drive the sheet-piling down through these hulks, an oak beam 6 by 10 in. sq. armed with a huge steel chisel, was first driven down as far as a steam pile-driver could force it. It was then withdrawn and a sheet-pile, 5 by 10 in. sq. was driven down in its place. The coffer-dam was formed of two courses of sheet-piling, 6 ft. apart, which were filled in between with clay. When this was completed, the water pumped out and the excavation prosecuted within it, the discovery was made that from one-third to one-half of the length of each of these three steamboat hulks was enclosed within the dam, and that some of the sheet-piling had not been driven through the lower one, owing to the great resistance of the hulk and the mass above it. Before the space between the lower wreck and the bed-rock could be made secure on the inner side of the dam, the water came through and flooded the inclosure. A stream from a powerful Gwynne pump, having an 8-in. diameter of jet, was then directed against the material deposited over these wrecks on the outer side of the dam, where the water was 15 ft. deep, and enough of the deposit was washed away to enable another course of sheet-piling to be driven down 6 ft. beyond the dam, through all of the

*Extracts from the forthcoming report of the Chief Engineer, Capt. James B. Eads.

wrecks to the rock. After this that part of the wrecks enclosed between this last course of piling and the dam, was removed by a diver and the space filled in with clay, and the inclosure again pumped out. This portion of the dam, about 50 ft. in length, was by this construction made double. As the excavation within progressed, it revealed the fact that another portion of the dam had been built and made water-tight through and over a water-wheel of one of the wrecks. The crank of an engine of 7 ft. stroke attached to the head of the shaft of the wheel, was just within the inclosure, while the flanges, arms, and braces of the wheel were within the walls formed by the sheet-piling. From the inclosure within the dam were taken parts of several old and burnt steamboat engines, the iron parts of some of which had to be cut off at the dam. Four wrecks of barges, some of them in use doubtless before the era of steam, were also found within it; likewise several oak saw-logs, some anchors, chains, and a great variety of smaller articles lost or thrown overboard from the river craft, or dumped in from the city.

This incongruous deposit made it exceedingly difficult to maintain the integrity of the dam, which at times had to resist a pressure of 30 ft of water. Frequent floodings consequently occurred which delayed and increased the cost of the work. These difficulties were, however, finally overcome, and the bed-rock within was at last exposed to view.

On the 25th day of February, 1868, after thoroughly testing the solidity of the rock by drilling, the first stone of your bridge was laid in this abutment 55 ft. below high-water mark, about four months after commencing the construction of the dam.

THE EAST PIER.

The caisson for sinking the East Pier having been completed, and the requisite guide piles, air and sand pumps, hoisting machinery, etc., being made ready, it was launched from the ways at Carondelet, on the 18th of October, 1869, and was towed up to its position in the river and duly secured within the guide piles on the same day. Some days more were occupied in securing the caisson to the suspension screws that were to steady it until it reached the sandy bed of the river, and in connecting the various air and water-pipes with it. On the 25th day of October, the first stone was laid upon it, from which moment until it reached the bed-rock of the river, on the 28th of February last (128 ft. below high water mark, or 120 ft. below the city directrix), the progress of its descent, and the working of the machinery connected with it, were marked by an almost total freedom from accident.

During low water the normal depth of sand over the bed-rock at this pier is about 80 ft. A rise in the river causes it to scour down, whilst a subsidence of the flood permits the moving sands from above to deposit rapidly and again raise the sand bed. At the time of placing the caisson in position the water in the river was 35 ft. deep, and 68 ft. of sand were then overlying the rock. As the caisson descended, the current sweeping under its bottom at the rate of about 3½ miles per hour, caused a further scour of 5 ft., leaving an irregular surface of sand, averaging about 63 ft. deep above the rock. When the caisson had fairly entered the sand a deposit was made rapidly around it, especially in the eddy created below the caisson. The sides of the caisson were swept to some extent by the current, otherwise the derrick boats on each side of it would have grounded on the deposit. This deposit was increased by the discharge from the sand pumps, and by the completion of the ice-breaker above the pier, so that for 20 or 30 days before it reached the rock, the sand was visible above the water, both above and below the caisson. The iron walls of the caisson had consequently a severe external pressure upon them from this mass of sand, and as the sides of the pier were inclined whilst the walls of the caisson were vertical, a space was left between the two. This space was at first occupied with bracings against the masonry to sustain the walls. As the pier descended and the pressure increased, sand from the pumps was discharged into it, and in this way the walls were relieved; the height of sand inside, between the caisson walls and the pier, being maintained at the level of the sand on the outside. The design was to keep the masonry constantly built up above water as the pier descended. The failure of the granite company to

deliver in time the granite which was intended to form the exterior of the pier above low-water mark, prevented me from following out this design. At the time the granite was wanted, the river was from ten to twelve feet above low-water mark, and there was left only the alternative of stopping the descent of the caisson that much above the bed-rock and awaiting the receipt of the granite, or else allowing the pier to descend and trust to the walls of the caisson to exclude the water above the top of the pier. Three courses of granite, each 2 ft. thick, were received in time, but when the pier reached the bed-rock the top of the masonry was about 6 ft. below the surface of the water.

To prevent danger to the workmen in the air-chamber, in the event of the walls of the caisson giving way under a pressure of water, a condition of things deemed possible, but not expected, the shafts or wells through the masonry, by which access was obtained to the air-locks which were at the bottom of the pier, were kept securely built up above the level of the water. On one or two occasions leaks occurred in the caisson walls, causing the top of the masonry to be flooded; but this precaution prevented a suspension of the work of filling the air-chamber under the pier with concrete, in consequence of such accidents, as the shafts remained free of water. During the month of April, however, the river rose to within 9 ft. 6 in. of the City Directrix, and was 19 ft. 6 in. above the top of the masonry. From the moment the caisson touched the rock up to this time, the filling of the air-chamber with concrete had been progressing almost without interruption. When the water reached this point, the walls of the caisson suddenly sprung a leak, and the pier was again flooded in a few moments. As the flooding of the pier usually increased the leakage in the shafts very much, it was not found practicable to continue work in the air-chamber when it happened, if the depth over the pier exceeded a few feet. When this accident occurred, the men were immediately signalled to come up from the air-chamber, then 110½ ft. below the surface of the river. This they did with entire safety. A suspension of work on the pier was then ordered until the water should subside.

Examinations of the caisson walls were made by our diver, Capt. Quigley, and careful soundings were made to ascertain the depth of the sand on the inside and outside of the caisson. It was then discovered that 55 ft. in depth of the sand on the east side of the caisson (on the outer side) had been scoured away by the action of the current, the soundings showing but 35 ft. of sand remaining above the bed-rock. This had reversed the strains on the caisson walls; the corresponding 55 ft. of sand on the inside between the pier and the caisson, had by its gravity burst out the eastern wall of the caisson, now no longer supported by the sand on the outside. This wall was of plate iron $\frac{3}{8}$ of an inch in thickness. This rupture renderd the further use of the caisson as a coffer-dam, forever after totally impracticable. The upper portion of it was consequently removed, and instead there was secured around the pier a wooden dam, joined together in sections corresponding to the sides and ends of the pier, and having a large cushion near its lower edge, on the inner side, to fit against the fourth joint of the masonry below the top course of the pier. This work was admirably executed under the direction of the Superintendent of Construction, Mr. W. K. McComas; the submarine work being very skilfully performed by Capt. Quigley. On the 13th of August the water was again pumped off from the top of the masonry. Since this time the pier has been carried up to the height of 117 ft. above the bed-rock on which it rests, and is now (October 1st) 19 ft. 9 in. above the present level of the river surface. The coffer-dam has been removed from around it, and no apprehension of further trouble from water during its completion need be entertained. It measures at its base, in the direction of the current, 82 ft. in length, and transversely 60 ft., and on the top at its present height, 75 ft. 7 in. by 35 ft. 1 in. It now contains 13,240 cubic yards of masonry, concrete, and brick work. The vertical wells or shafts through it, were lined with brickwork from 13 to 22 in. in thickness. These openings were carefully filled up with concrete and the entire pier is now one solid mass of masonry.

In addition to the almost constant presence of the Superintendent of Construction, in charge of all the works, it was

made the duty of three civil engineers, familiar with the plans, machinery, etc., to give their personal superintendence to the sinking of the pier; one being constantly on duty, watching the progress of the work, and keeping a record of everything of interest occurring. The necessary number of steam engineers, machinists and firemen, were employed for keeping the engines at work night and day, and the machinery in perfect order, so that the work could go on without any interruption whatever. To accomplish this desirable object, sufficient duplicate pumps, engines, boilers, etc., were provided, so that the failure of any one piece of the machinery would cause no stoppage in the progress of the work. The pier was placed on the rock in 126 days after the laying of the first stone, which period included the most inhospitable season of the year. The mason work was suspended during 20 days of this time on account of bad weather. During 15 days it was impossible to tow a barge of stone to the pier on account of the running ice.

TELEGRAPH.

When this pier had reached the depth of 66 feet, a telegraphic instrument was placed in the air-chamber, and a wire was led to the office of the Superintendent of Construction on one of the derrick boats at the pier, and also to the office of the Chief Engineer in the city. By this means messages were transmitted to and from the air-chamber, and between the offices of the Superintendent of Construction and that of the Chief Engineer, by which I was, when not present, regularly advised of the progress and condition of the work during the sinking of the pier. The knowledge that a means of communication with the upper world was constantly at hand in the air-chamber, and one which was not likely to be interrupted by any accident endangering the lives of the workmen in it, was productive of a very salutary moral effect upon them.

These telegraphic arrangements were courteously put up complete under the gratuitous superintendence of Col. Chas. H. Haskins, General Superintendent of the Pacific and Atlantic Telegraph Company. The instruments were of the kind known as "alphabetical," and were easily understood and operated by those placed in charge of them in the service of the Bridge Company.

FILLING THE AIR-CHAMBER.

The filling of the air-chamber was executed in the most careful and substantial manner under the immediate direction of the Superintendent of Construction. The preparation and disposition of the concrete were made in the air-chamber (from 103 to 110½ ft. beneath the surface of the river), under the immediate supervision of Mr. Rud. Wieser, C. E., Chief Inspector of Masonry, and his assistants, Mr. Rich. Richardson and Mr. Fritz Eberley, master masons, one or the other being constantly on duty. From frequent personal inspection, I am warranted in saying that this part of the work is unsurpassed in excellence by that of any part of the masonry above water.

The filling of the air-chamber with concrete commenced on the 2d day of last March, and was finished on the 27th of last May. The working time being 53 days. The space filled may be fairly stated at nearly 36,000 cubic ft. The area of the base of the pier is 4,020 sq. ft. and the height of the chamber 9 ft. The caisson was stopped as soon as it touched the bed-rock. This was at its southwest corner. At the northwest corner its edge was 8 in. from the rock. The northeast corner was 16 in. and the southeast 8 in. It will be seen from this that the rock was, fortunately, very nearly level. The sand beneath the edge of the caisson was removed, the rock laid bare and the space filled carefully with concrete, the air pressure being sufficient to prevent a more rapid infiltration of the water under the edge of the caisson than could be managed by the pumping arrangements within it. The sand seemed packed so firmly that no trouble was taken to barricade it out of this space between the rock and the edge of the caisson. When the entire edge of the caisson and the space under its two great girders were thus concreted, the rock in its interior was gradually cleared of sand and the concrete placed directly upon it in layers of 9 or 10 in. in thickness, the closing courses under the roof of the chamber being stoutly rammed in place. The air-locks were then filled with the same material, and finally the shafts. The concrete was made

of broken limestone thoroughly washed, the interstices being filled with mortar made of equal parts of Akron cement and pure sand.

During the sinking of the pier the sand pumps designed by me for this special purpose, gave great satisfaction and proved entirely successful. One pump of 3½ inches bore was found quite capable of raising 20 cubic yards of sand 120 ft. high per hour; the water pressure required to supply the jet being about 150 lbs. per sq. in.

PRESSURE IN THE AIR-CHAMBER.

The pressure of air in the air-chamber was very accurately determined by the depth of the caisson below the surface. Any greater pressure than that due to the depth, caused the air to escape beneath it, but when the caisson had penetrated into the sand to a considerable distance, it was discovered that the water level formed by the air under or across the bottom of the chamber was nearly a foot lower than the bottom edge of the caisson. When the caison was but a few feet in the sand, the air forced its way up by its sides in one or two currents of large volume, but as it penetrated more deeply, the passage of the air through the sand evidently became more difficult, and it appeared in small bubbles 60 or 70 ft. distant from the caisson. This retardation of the escapement of the air from beneath the caisson, caused an increase of air pressure by which the water was held at a greater or lesser depth below the line of the bottom of the air-chamber. The sand inclosed in the air-chamber and forming its floor was usually 1 or 2 ft. more elevated than the lower edge of the chamber, and was entirely devoid of water, the air pressure expelling the water from it down below the edge of the caisson as just stated. The distance to which it was thus expelled and maintained, was at no time discovered to exceed 10 in., and generally it was not over 8 in. This would give an air pressure equal to nearly 1 ft. more than the depth of the caisson, or about ½ of a pound per square inch more. This difficulty of escapement of the air through the sand was increased somewhat by concreting under the edge of the caisson on the rock, and the actual air pressure could then be no longer accurately determined by the height of the water above. The pressure gauges usually indicated a pressure of 1 or 2 lbs. more than the depth of water would give by calculation. This was caused in a great measure, however, by the friction of the air in the pipes, the gauges being at the pumps and not in the air-chamber. A column of water 110 ft. 6 in. in height would be equal to a pressure of 47.96 lbs. per square inch, assuming the weight of the water to be 62.5 lbs. per cubic foot. The greatest pressure marked by the gauges was 52 lbs., and it is not probable that the pressure in the air-chamber ever exceeded 50 or 51 lbs.

EFFECTS OF COMPRESSED AIR ON THE MEN.

The first symptom manifesting itself, caused by the pressure of the air, is painfulness in one or both ears. The Eustachian tubes, extending from the back of the mouth to the bony cavities over which the drums of the ears are distended, are so minute as not to allow the compressed air to pass rapidly through them to these cavities, and when the pressure is increased rapidly, the external pressure on the drums causes pain. These tubes constitute a provision of nature to relieve the ears of such barometric changes as occur in the atmosphere in which we live. The act of swallowing facilitates the passage of the air through them, and thus equalizes the pressure on both sides of the drums, and prevents the pain. The pressure may be admitted into the air-lock so rapidly that this natural remedy will not in all cases relieve it. By closing the nostrils between the thumb and fingers, shutting the lips tightly and inflating the cheeks, the Eustachian tubes are opened and the pressure on the inner and outer surfaces of the tympanum is equalized, and the pain prevented. This method must be used and repeated from time to time as the pressure is let on, if it be increased rapidly. No inconvenience is felt by the reaction when the pressure is let off, as the compressed air within the drums has a tendency to open the tubes, and thus facilitates its escape through them; whereas increasing the pressure has the effect of collapsing them, and therefore makes it more difficult to admit the compressed air within the cavities of the ears. It frequently occurs, however, from some abnormal condition of these tubes, as when inflamed by a cold in the head, that neither of these remedies will relieve the pain.

To continue the admission of compressed air into the lock, under such circumstances, would intensify the suffering, and possibly rupture the tympanum, therefore the lock tenders were particularly instructed to shut off the compressed air at the moment any one in the lock experienced pain about the ears; and then, if it could not be relieved by the above means, the lock was opened and the person was not permitted to go through into the air-chamber. Sometimes 15 min. were occupied in passing persons through the first time, after which they usually had no further trouble from this cause.

The fact that the depth penetrated by the air-chamber was considerably greater than that hitherto reached in any similar work, left me without any benefit from the experience of others, in either guarding against any injurious effects of this great pressure upon the workmen and engineers subjected to it, or of availing myself of any known specific for relieving those affected by it. When the depth of 60 ft. had been attained, some few of the workmen were affected by a muscular paralysis of the lower limbs. This was rarely accompanied with pain, and usually passed off in the course of a day or two. As the penetration of the pier progressed, the paralysis became more difficult to subdue. In some cases the arms were involved, and in a few cases the sphincter muscles and bowels. The patients also suffered much pain in the joints when the symptoms were severe. An average of at least 9 out of 10 of those affected, suffered no pain whatever, but soon recovered, and generally returned to the work.

The duration of the watches in the air-chamber was gradually shortened from 4 hrs. to 3, and then to 2, and finally to 1 hr.

The use of galvanic bands or armor seemed, in the opinion of the Superintendent of Construction, the foreman of the chamber, and the men, to give remarkable immunity from these attacks. They were all ultimately provided with them. These bands were made of alternate scales of zinc and silver, and were worn around the wrists, arms, ankles and waist, and also under the soles of the feet. Sufficient moisture and acidity were supplied by the perspiration to establish galvanic action in the armor, and as the opinion among those most accustomed to the chamber was almost unanimous in favor of this remedy, I am very much inclined to believe it valuable.

Immediately on the manifestation of greater severity in the symptoms, a hospital boat was fitted up at the pier, and one of the ablest physicians in the city (Dr. A. Jaminet) was engaged to attend those affected, and also to institute such sanitary measures as his judgment should dictate. A careful examination of the health and bodily condition of every workman was daily made, and none were permitted to engage in the work without the approval of Dr. Jaminet. Those most severely affected were sent to the City Hospital and had the benefit of the advice and treatment of its resident physician, Prof. E. A. Clark. The total number of men employed in the air-chamber of this pier was 352. Of this number about 30 were seriously affected. Notwithstanding the care and skill with which those most severely attacked were treated, 12 of the cases proved fatal. Each one of these, without exception I believe, was made the subject of careful inquest by the coroner, aided by an autopsy conducted usually by some of our most skilful surgeons and physicians. Whilst the exciting cause in all of these cases was doubtless the exposure of the system to the pressure of the condensed air of the chamber, the habits and condition of several of those who died were at the time they went to work, such as would have excluded them from it if subjected to the examination of Dr. Jaminet, and the verdict in about one-half of the cases gave a totally different cause for the death of the patient. Nearly or quite all of these deaths happened to men unaccustomed to the work; several of them to men who had worked but one watch of 2 hrs. In contrast to this, is the fact that quite a large number of the men (certainly one-half of those constantly employed) commenced with the work at its inception and remained throughout its continuance entirely without injury or inconvenience.

The gentlemen composing the engineer corps of the bridge all visited the air-chamber, some of them quite often, either in the discharge of their professional duties, or from motives of curiosity, and none of them suffered any injury whatever.

Much diversity of opinion was expres-

sed by the medical gentlemen who investigated the symptoms and held autopsies of the deceased. Some of these gentlemen maintained that a slower transition from the abnormal to the natural pressure would have been less injurious; others claimed, on the contrary, that it was from the too rapid application of pressure in passing from the natural into the compressed air. The fact that the air-lock tenders were in no case affected, although subjected many times during a watch of 2 hrs. in the air-lock to rapidly alternating conditions of the atmosphere, at one moment in its normal state in the lock, and five minutes later exerting a pressure of 50 lbs. per sq. in. upon every part of the body, would seem to prove both of these theories unsound, and lead us to believe that in the length of time to which the human system is subjected to this extraordinary pressure, exists the real source of danger, and not from any rapid alternations of pressure to which it is exposed. After the caisson reached the rock, I have frequently, when passing through the air-lock, admitted the compressed air into it so quickly that none but those well accustomed to it could relieve the pressure upon their ears, and yet I felt no ill effects whatever from this rapidly increased pressure; and, in going out, I have let the pressure off so fast that the temperature in the lock has fallen 32 deg. (Fahr.) in consequence. These transitions occupied but 3 or 4 min.

The fact that the air-chamber was briefly visited by thousands of persons, including many delicate ladies, even after it had reached the bed-rock—some remaining as long as an hour in it without any of them experiencing the slightest ill effects from the pressure—and the fact that no cases of any importance whatever occurred among the workmen after the watches were reduced to 1 hr., satisfies me that this is the true cause of the paralysis, and that by lessening still more the duration of the watches, a depth considerably greater can be reached without injury to the workmen. Too long a continuance in the air-chamber was almost invariably followed by symptoms of exhaustion and paralysis. Dr. Jaminet, on one occasion, remained $2\frac{3}{4}$ hrs. when the depth was over 90 ft., and was dangerously attacked soon after reaching home.

Symptoms of paralysis rarely occurred in the shaft, but generally after the stairs were ascended, and never in the air-lock or air-chamber.

A large amount of money has been gratuitously expended by the Company in assisting and providing for those who were seriously affected, and in relieving the wants of their families during their illness.

As a merited recognition of the courage, fidelity, and services of the men employed in the air-chamber of the East Pier, and as an evidence of my personal appreciation of their faithfulness and good conduct, I have placed in the appendix to this report, the names of those engaged in the work when the pier reached the rock.

THE WEST PIER.

The sinking of the West Pier began on the 15th day of January of last year, that being the day on which the first stone was laid on the caisson. As it was commenced 12 weeks later than the East Pier, advantage could be taken of the experience gained in sinking the latter. On the East Pier the interruption and annoyance caused by the necessity of riveting on the iron plates outside of the masonry, to exclude the water as the pier descended, led me to devise some means whereby this inconvenience might be prevented, and the cost of the iron saved. The design of the West caisson was so modified that the use of these plates could be abandoned, after the first 29 ft.; 9 ft. of this height being the air-chamber, and the remaining 20 ft. enveloping the masonry above the chamber. This height of plate iron was deemed requisite to give such rigidity to the caisson as would insure it against any twisting or straining that would endanger the bond of the masonry. After a depth of 40 or 50 ft. was reached by the East Pier, it was found evident that brick linings in the shafts, although surrounded by many feet of masonry, carefully laid in hydraulic cement, were not sufficient to exclude the water, which, at this depth, filtered through quite rapidly. To prevent this, and to enable the iron around the outside of the pier to be dispensed with on the West Pier, its shafts were lined with white pine staves, 3 in. thick in the centre shaft, which was 10 ft. in diameter, and $2\frac{1}{2}$ in. thick in the smaller wells, which were 4

ft. 9 in. in diameter. This device answered admirably, and the estimated saving in plate iron, over the original design, was about $10,000. The lower staves were, however, found to be too weak to sustain the high water of the Spring freshet, without expansion bands of 1x3 in. bar iron, which were placed against them in the shafts in time to avoid any disaster. This novel feature of wooden linings, and no exterior envelope for the masonry, will be introduced in the East abutment. The caisson for it is, however, made so strong, that the iron will only be brought up to a height of 12 ft. around the base of the masonry. The lining staves in its wells will be so much stronger, that they will require no internal supporting rings of iron.

Nothing could have exceeded the perfect working of these economic improvements in sinking the West Pier had not the contractors failed to deliver the granite for it in time. When the point was reached at which the granite became necessary, the surface of the masonry was 6 or 8 ft. above water and the base of the pier 18 or 20 ft. from the rock. A judicious view of the case, having reference solely to the cost of constructing this pier, would have dictated a suspension of the work until the stone should have arrived, rather than continue the sinking of the pier and suffer the top of the masonry to descend below the surface of the water. Other questions however, were involved of a more serious nature. It was universally conceded that any effort to negotiate the securities of the Company would be fruitless unless preceded by an absolute demonstration of the practicability of putting down the channel piers of your bridge upon the bed rock of the Mississippi, through the unusual depths of water and sand that were to be encountered. The East Pier was in a similar condition at this time, and there remained no alternative but to continue sinking both, to do which it was necessary to build up and brace out the iron plates which had been carried up from the air-chamber around the masonry of the last pier, and thus dam out the water from covering the top of the masonry as it descended below the surface of the Mississippi, so as to be able to resume the laying of stone when the granite should arrive; and as the West Pier was without any such iron envelope, it became necessary to attach the wooden walls of a coffer-dam to its sides in such a manner as to exclude the water from the top of the pier. This was done by padding the lower edge of the dam and attaching its sides securely to the masonry, several courses below the top. This answered very well until the last 9 inches of this pier was sunk to the rock. Some of the bolts holding down the dam at the south end of the pier gave way, and the friction of the sand, then 14 ft. high on the outside of the dam and nearly to the surface of the water, prevented the settlement of the dam with the pier at this particular point. Two outside courses of the limestone to which it was attached were held up by the dam nearly across the entire end of the pier. This mishap made it necessary to pump away the sand outside this end of the dam, and put down a large pad or wooden covering reaching below the two disturbed courses, then pump out the dam and relay them. This was done at a depth of about 17 ft. below the surface. The dam was not pumped out till the granite arrived, as the water over the pier did not prevent the work in the chamber, access to it being obtained through the wooden shafts or wells which passed down through the water that was over the masonry. This unexpected trouble, and that at the east pier, were caused solely by the failure of the Richmond Granite Co. to deliver the granite in time. Its delivery was due several months before it was needed, and yet it was not delivered until several months after it was wanted. The loss to your Company, resulting from this failure, I estimate to amount to at least $50,000.

THE EAST ABUTMENT PIER.

The complete success which attended the sinking of the East Pier convinced me of the practicability of sinking the east abutment pier to the rock in the same manner. The original plans of the bridge did not contemplate resting this abutment on the rock. It was believed quite practicable to protect its foundation with riprap stone, and to secure stability and safety by resting it on piles, which were to have been driven to a distance of 50 ft. below low-water mark. When the Directory of the Company were assured of the practicability of resting this abutment upon the bed-rock itself, and of thus terminating

for ever all doubts as to the absolute stability of each one of the four great piers of your bridge, the desire that this, the largest of them all, should be placed on the rock also, was unanimous; although the excess in cost involved over that of the original design was understood to be about $175,000. No less than 10,000 additional cubic yards of masonry *below* the line of the tops of the piling on which it was originally intended to start the masonry, are required to sink the pier to the rock. Consequently below this line, it will require nearly as much masonry as will be contained in the west abutment when the latter is completed.

This abutment, when completed, will contain 22,453 cubic yards of masonry, including concrete and brick-work, and will measure in height, from the rock to the top of its cornice, 196 ft. 9 in.

The depth of the rock at the site of the abutment was ascertained by careful borings to be 8 ft. lower than that at the East Pier, or 136 ft. below high water mark.

It is not probable that we shall have to contend with much deeper water or much greater air pressure than that encountered in sinking the East Pier. The bed-rock at this abutment is 94 ft. below extreme low-water mark, and the river is not likely to be more than 18 ft. above that during the seasons occupied in sinking the pier. Extreme low-water mark is only reached when the river is gorged with ice above the city, and the volume of water below the gorge becomes in consequence greatly lessened. The ordinary low water rarely reaches a point within five feet of low-water mark.

In accordance with the wish of the Directory, preparations for sinking this abutment to the rock were commenced, and are now nearly completed. The caisson is nearly ready for launching, after which it will be immediately towed into position, and be made ready for sinking. It will cover when on the rock, 5,000 sq. ft. of surface, and is therefore about one quarter larger than the base of the East Pier. A large trestle work has been erected immediately east of the site of this abutment, extending a few feet above high water mark, on which is being placed a portion of the necessary machinera for sinking the caisson. This trestle-work was rendered necessary because of the shallowness of the water on that side of the abutment. On the west side of the caisson one of the derrick boats used at the East Pier will be located, and on the trestle-work will be placed much of the machinery of the other derrick boat, which was used on the other side of the East Pier.

THE EAST ABUTMENT CAISSON.

This caisson will have several novel features in its construction, which I think will make it superior to those used for the East and West Piers. The main shaft will have at the bottom 2 air-locks, each 8 ft. in diameter, instead of one of but 6 ft. The main shaft will be carried down into the air chamber 10 ft. in diameter, instead of but 5 ft.

The East Pier caisson had 6 other shafts of 4 ft. 9 in. in diameter, with air-locks of the same diameter at the bottom of each. This caisson will have but 2 other shafts of 4 ft. in diameter, with an air-lock at the bottom of each, 8 ft. in diameter. These last 2 shafts are enlarged below the roof of the air-chamber to 8 ft. in diameter each. The increased diameter of the locks will contribute to the health of the men, as it is sometimes necessary for 12 or 14 of them to be in one of them at the same time, for several minutes, until the pressures are equalized. As all 4 of these locks are within the air chamber, and also the lower ends of the 3 shafts, and as about 1,800 cubic ft. of space is occupied by them, there will be that much less space to fill in the compressed air when the pier is down.

The centre shaft alone will be used for the workmen, unless some unforeseen accident should render it necessary for them to use one or the other of the side shafts, which are provided almost solely for safety. The extra size of the locks makes either one of them capable of holding in an emergency all the men that will be in the air-chamber at one time, and hence their security will be increased.

To avoid the labor of walking up a circular stairway about 120 ft. high after leaving the air-chamber, the main shaft, in addition to the stairway, will have an elevator, or lift, to bring the men up. This, it is believed, will contribute greatly to their health. When they are at work in a pressure of 45 or 50 lbs. above that of the natural atmosphere, there ensues a rapid exhaustion of the physical ener-

gies. When relieved from duty, a considerable degree of prostration is frequently manifested, and the foremen of the different gangs were in consequence instructed by the physician to cause the men to ascend the stairs leisurely, to avoid increasing it. I confidently believe, therefore, that by bringing the men to the surface in the elevator, there will be much less danger of injury occurring from their employment in the air-chamber.

LIGHTING THE CAISSON.

A different method of lighting the air-chamber will likewise be adopted. In the other caissons much inconvenience was experienced on account of the particles of unburned carbon thrown off from the flames of the candles used. The consumption of the candles under the action of the compressed air was much more rapid than in the normal atmosphere. At the depth of 100 ft., they were found to be consumed in about $\frac{3}{5}$ of the time required in the open air. Large quantities of smoke were emitted from the flames, and the air was filled with particles of floating carbon, which could only be removed thoroughly by placing a rose jet on the nozzle of a water hose in the chamber, and discharging the spray in every direction. Some amelioration of the evil was obtained by burning the candles under an inverted funnel or chimney, communicating with one of the shafts by a small outlet pipe, through which the escape of the compressed air was regulated by a cock, thus creating a draft above the flame by which the smoke was carried off.

The calcium light would probably prove the most satisfactory one which could be employed in the chamber, were it not for the excessive cost of it in this city. For the 150 days which will be required in sinking this pier and completing its foundation on the rock, the cost of lighting the three compartments of the chamber with calcium lights, would be at least $5,000. By the means devised for the purpose, the cost cannot exceed one-fifth of that sum.

The difficulty of extinguishing a flame in an atmosphere of such density, caused me to forbid the use of oil lamps in the chamber before a depth of 80 ft. had been reached. The clothing of two of the men having taken fire from contact with some of the hand lamps or candles used in the caisson, it was found exceedingly difficult to extinguish the flames. One of them was severely burned, although his garments were almost entirely woolen. It was deemed unsafe to risk the danger of having the clothing of the men saturated with oil from the accidental breaking of a lamp which might, by the same casualty, ignite their garments and thus endanger their lives. The use of oil was therefore forbidden.

At the depth of 80 ft. it was found that the flame of a candle would immediately return to the wick after being blown out with the breath. At the depth of 108½ ft. below the surface of the river, I blew out the flame of one of them thirteen consecutive times in the course of half a minute, and each time, excepting the last, it returned to its wick. Almost as long as a small portion of the wick remained incandescent, the flame would return, and when the glowing particle of two separate candles failed to possess sufficient heat to restore the flame to either, it would reappear at once by placing the luminous portions of the two wicks in contact.

The chamber of this caisson will be lighted by candles contained within glass globes of similar construction to those used in lighting railway carriages. The glass will be of strength sufficient to sustain the external pressure of the condensed air. The chimney will consist of an outlet pipe of 1 in. diameter, communicating with one of the shafts, and the compressed air will only be admitted within the globe in which the candle is placed, through a small regulating valve. The candle will therefore be burning under the normal pressure of air. A stopcock in the chimney will prevent the escape of air from the chamber through the globe, when it is desirable to put in another candle, or to clean the glass.

TIMBER WORK.

Beneath the masonry piers of suspension and truss bridges, it is quite common to employ a considerable amount of timber. Where the pressure upon the pier is a vertical one, this economical substitute for stone is admissible, but in the piers of an arched bridge, where some one span is at times loaded while the others are unloaded, the thrust of the loaded arch has a tendency to oscillate the piers,

and with a few feet in thickness of a material so elastic as wood under their bases, this oscillation would prove a dangerous feature. In the abutment piers where the thrust is only from one side, and oscillation is prevented by the works on shore, timber may be safely used to a considerable extent. To give the desired stiffness to the caisson for this abutment and avoid the more costly use of iron, the roof of the air-chamber is made of timber 4 ft. and 10 in. in thickness. A large amount of timber is also used in constructing and stiffening the sides of the air-chamber, which are 10 ft. high, and in forming two horizontal trusses or girders through the air-chamber. These two girders are each 10 ft. thick at the top, 3½ ft. at the base and 9 ft. in height. They are about 73 ft. long and are interlocked at each end with the sides of the air-chamber. They divide this chamber into three nearly equal compartments in the direction of the length of the bridge. Communication is made between these compartments by means of two openings through each girder.

The sides of the chamber are 8½ ft. thick at the top and 18 in. at the bottom, and are composed of timbers, some placed vertically, others horizontally, and some inclined at an angle of about 45 deg., and the whole, including roof and girders, thoroughly interlocked together, and bolted with large iron bolts. All of the timber is of the very best white oak, and was squared up with two steam planers belonging to the Company. In addition to the iron bolting used, these timbers are thoroughly secured together with large white oak tree-nails.

The wood work of the caisson has been most admirably executed under the superintendence of Mr. John Dunlap, master of ship-carpenters.

PLATE IRON WORK.

Enveloping this entire wooden structure is an iron covering riveted together to prevent the escape of the air which is to supply the workmen. This is of ⅜ in. plate iron, and its sides are increased in thickness at the bottom edge to three in., by riveting 4 ¾ in. plates together. These extend several ft. up the sides. This iron edge extends 10 in. down below the wooden sides and forms the cutting edge of the caisson. Every 2 ft. the iron sides are strengthened by vertical angle irons 3 by 7 in. in size, riveted on flatwise on the outside of the caisson. Through these angle bars, bolts 1½ in. in diameter are inserted, and by them the iron and wooden sides are strongly held together. This iron covering extends over the wooden top of the air-chamber and forms a floor on which the masonry will be laid. The 3 shafts passing through this floor, by which access to the chamber is obtained are tightly riveted to it.

The iron sides are carried up 12 ft. above this floor, where they will terminate. The masonry above this point will therefore have no exterior envelope such as the East Pier had.

Nearly all the iron used in this envelope was obtained from the hull of the iron gun-boat Milwaukie, the wreck of which was purchased about 18 months ago. This iron work has been executed by Capt. Wm. S. Nelson, the skilful and energetic contractor who built the caissons of the two channel piers.

WATER-TIGHT LININGS.

The water penetrating the masonry will be excluded from the 3 shafts by white pine linings, arranged like the staves of a cask. The staves composing this lining in the main well or shaft, which is 10 ft. in diameter, will be 10 in. thick in the lower part, and will be gradually diminished to 3 in. at the top. In sinking the pier, the top of the masonry and shafts, will be kept constantly built up above the surface of the river.

FILLING THE AIR-CHAMBER.

The most valuable improvement in the design of the caisson will I think, be found in the method devised for filling the chamber when it has reached the rock. It is a well established fact that sand constitutes one of the most reliable and durable materials for foundations known, if availed of in positions where it can be securely retained under the structure erected upon it. It is an equally well-established fact that timber when entirely submerged in fresh water foundations, is indestructible. These two facts will be relied upon in filling the air-chamber and fixing the foundation of this pier upon the rock. Instead of concrete, sand will be chiefly used for filling the chamber. The sides of

the caisson are of great thickness, and are thoroughly interlocked at the corners of the air-chamber, and at the ends of the girders. The possibility of the sand surrounding the pier ever being scoured out to the rock, at the site of this abutment, is a very remote one. It is certainly much more improbable than that it may be scoured thus deeply at the sites of the two channel piers. To avoid all danger from this very remote possibility throughout all time, whatever space there may be existing between the timber walls of the caisson and the bed-rock, after the caisson shall have reached it, will be thoroughly concreted, so that these walls will have a substantial bearing upon a solid material which cannot be affected by any current that may possibly wash the base of the pier. The walls of the air-chamber are so framed as to be sufficiently strong to resist the bursting pressure of the sand within the chamber, caused by the weight of the masonry of the pier and half the side span upon it, even after all the iron used in it shall have been corroded away. The base of the pier is 5,000 sq. ft. in area, and the weight of the entire pier including ½ of the span, will be about 46,500 tons. The pressure per sq. ft. on the rock would, therefore, be 18,600 lbs. The area of the wooden edge of the caisson, including that of the bottom of the girders, air-locks and shafts, is about 1,250 sq. ft. This area alone would be capable of sustaining the pier, without any additional support from the sand contained within the air-chamber. Without this sand filling, the pressure upon the wooden base of the caisson (including the locks and shafts) would be about 74,000 lbs. per sq. ft. or 514 lbs. per sq. in. This pressure is not beyond the power of good white oak to resist, nor would it be sufficient to crush the concrete that will be used in filling the small space between the oak and the rock.

Tests made with our testing machine upon a number of blocks of concrete only six weeks old, gave an average resistance to crushing, equal to 1,200 lbs. per sq. in. Of course, with the integrity of the exterior of the caisson unimpaired, the escape of sand from the interior would be impossible. With the interior compactly filled, the pressure of the superincumbent mass must necessarily be very nearly equally distributed over every part of the caisson, and hence it cannot exceed about 18,600 lbs. per sq. ft.

The tedious process used in concreting the air-chamber of the channel piers, together with the objections to working men at such great depths, induced me to devise some method by which a smaller amount of manual labor could be made to accomplish equally good results. By the plan determined on in this case, I confidently hope to accomplish the necessary work in the air-chamber with a 5th or 6th of the manual labor which was required under the East Pier.

This method is so simple as to be readily explained. So soon as the rock shall have been struck by the iron edge of the caisson, the space then remaining between the wooden walls of the caisson and the rock, will be thoroughly concreted. The sand under the two girders will be left intact. The borings indicate that the rock is quite level, and it is not probable that inequalities of more than 18 in. will be found in it. It is estimated that 100 cubic yds. of concrete will be sufficient to support these walls, forming a bed of an average width of 3 ft. 6 in., by 2 ft. 6 in. in height. This concreting being done, all the pipes passing vertically through various parts of the pier, and used for air, water, and sand-pumps, will be closed at the top, and the pumps, valves, and pipes connected with them in the air-chamber, will then be taken off. There will be 19 of these vertical pipes, each either 4 or 6 in. in diameter, the lower ends of which will be enlarged conically through 5 ft. of their lengths. These pipes being opened at their lower extremities, and one of the inner doors of an air-lock being secured from being clogged by sand, the air from the chamber will be permitted to escape, and the chamber will be filled with water. This being done, sand will be introduced through the various vertical pipes mentioned. By means of plummets in these pipes, we shall be able to determine the height of the sand discharged in them, and when it is near the roof of the chamber, the air will be again pumped in, and workmen will be sent in to level it off. By repeating this process two or three times, the chamber can be filled nearly to the roof with sand compacted in the water, which will insure its solidity. The remaining space can then be filled with

concrete, rammed in under the roof of the chamber. The great thickness of the walls, and of the girders, where they join the roof, reduces the area of the upper part of the chamber very greatly. The upper 3 ft. of it measures only 2,025 cub. ft. in area, exclusive of the air-locks and shafts.

To fill the air-chamber of the East Pier, required 1,340 cub. yards of concrete, which was placed in position by manual labor, under an air pressure of nearly 50 lbs. per sq. in. Ths pier is 25 per cent. larger, and will require only about 200 yards of concrete to be placed in it under similar conditions; hence the work required to be done in this chamber will be greatly less than in that of the East Pier.

MUTUAL PRESSURE OF LIQUIDS AND SOLIDS.

Translated from "Exposè de la Situation de la Mecanique Appliquée."

That division of hydraulics which considers the mutual reactions of solids and liquids in relative motion has made small progress. Theory yields to observation, and empirical formulas. Yet the fundamental problem of determining the normal pressure of a liquid vein spreading over an indefinite plane, has been rigorously solved. The theorem of projected quantities of motion, gives the sum of the normal actions of the plane upon the vein, and shows that it is composed of two parts; one representing what may be called the static pressure of the water, is due to the component of weight taken perpendicular to the plane; the other is the dynamic pressure, and is expressed by a term containing as factor the square of the velocity of the current. It is seen that the pressure would be less if the plane, instead of being indefinite, allowed the liquid filaments to escape in the direction of their primitive motion; and that it would be greater, if instead of the plane there should be substituted a concave surface reflecting the filaments into an opposite direction.

This problem of impact of a stream against a plane being solved, attempts are made to refer to it analogous practical problems, in which we have to consider the action of a liquid current impinging upon a body of any form.

The earliest experiments in the reactions of water and bodies immersed in it were those of Dubuat. This celebrated hydraulic engineer caused planes and solids of various forms and dimensions to move in still water, and determined in each case the co-efficient with which to multiply the product of the transverse section and the square of the velocity, in order to obtain the measure of resistance. If the solid has a prismatic form, the phenomena are made more complex by the friction along the lateral faces. Tapering towards the extremities reduces the value of the co-efficient of resistance. Long experience in navigation has determined the most advantageous forms for the keel of a ship.

In canals resistance to traction depends not only on velocity and section of boat, but also upon the section of the canal; traction being more difficult, with equal section, upon a narrow, than upon a wide canal. It has been found that beyond a certain velocity traction decreases rapidly. This velocity is that of the motion of the wave caused by the floating body upon the surface of the water. This was profitably applied in the Canal de Ourcq, between Meaux and Paris, in running the boats carrying the mail. Such a velocity is not practicable with freight boats.

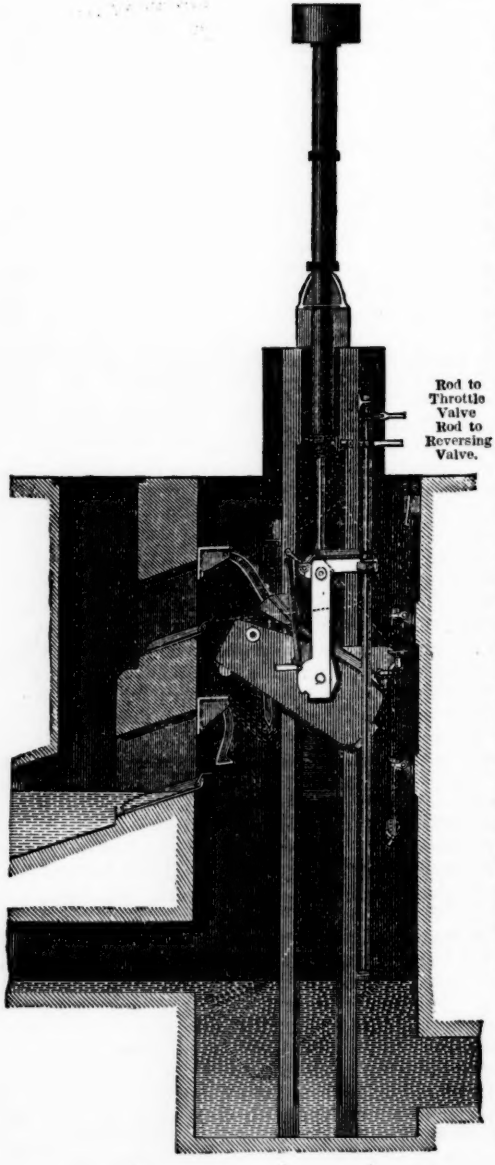
Dubuat made experiments of two kinds; in one he placed the solid body upon the surface of calm water; in the other he fixed the body firm in a stream of water. Comparison of results showed a slight difference between the mutual reactions consequent upon equal relative velocities. From this he drew a paradoxical consequence, contradictory to the laws of relative motion: "In the condition of rest water offers more facility of division, and therefore less resistance, than when it is in motion."

The phenomenon as stated by Dubuat is actual, but the conclusion is false. The reason of this singular phenomenon is now known. In running water the liquid filaments have unequal velocities; while, if a body is moved in still water, the relative velocity of the water is the same for all the filaments. The relative situations are not the same, and the difference of resistances observed does not contradict the laws of mechanics.

HYDRAULIC BUCKETTING ENGINE.

By PERCY WESTMACOTT.

From "Engineering."



During the construction of the Herculaneum Graving Docks, Liverpool, in the year 1863, Mr. George Fosbery Lyster, the dock engineer, communicated with the writer respecting the mechanical appliances for emptying these docks. The application of hydraulic power to the gates and capstans, etc,, having already been decided upon, it was considered expedient to contrive the emptying of the Graving Docks in conjunction with this same system, and thus save the erection of another steam-engine and plant for this special service, and at the same time secure a ready means of applying power especially at all times to serve leaks. Some arrangement, too, was required that would overcome or, at any rate, diminish the difficulties and inconveniencies experienced in dealing with water charged with rubbish from Graving Docks. The result was the construction of a machine upon a principle of bucketting large quantities of water at a time, devoid of clack valves, gratings, or other parts liable to choking or injury by floating matter, and that could be lifted clean out of the water to give free access to all parts when required. By this principle the same weight of water is discharged at each stroke, and thus no undue loss arises from the application of a constant hydraulic pressure, nor does the strain upon the parts or the conditions in working vary with the fall of water in the dock.

A scoop-shaped bucket attached to a piston rod is plunged at an angle of slight resistance into the water, and by a self-acting arrangement is turned round at the proper level, fitted, raised, and then discharged over an apron. The bucket of this engine, repre-

sented upon the accompanying outline plan, holds 14½ tons of water, and is constructed of wrought iron. It is poised upon a shaft attached to a sliding frame working in guides, suspended in the centre by the piston rod of the vertical cylinder which is planted above the well. The bucket when dropping is about equally poised on its axis, but when full and lifting, the back part is slightly in excess in weight. It is held firmly in position in plunging and lifting by means of catches which fall into a two-notched catch plate fixed on either side of the sliding frame. In plunging, these catches are, at the right moment, thrown out of gear by a float attached to the bucket, and in discharging they are disengaged by tappets fixed to the sides of the well. The weight of the float when out of the water forces the catches into the notches. Under the nose of the bucket another small float is fixed for the purpose of swinging the bucket quickly round to fill so soon as the catches are thrown out of gear by their float, and to bring this motion of the bucket up gradually, wooden floats are attached at the back which also serve to steady the bucket as the catches fall into gear. Check chains fitted with springs are applied to either end of the bucket. To insure the catches falling into place for the plunge, a cam on the bucket is made to strike a tappet fixed at the back of the well, should the bucket in swinging round not angle sufficiently in itself for the catches to fall into gear. The bucket with its attachments is counterbalanced by weights rocking in the guides of the well. In discharging, the catches are thrown out of gear by tappets, and 2 rollers in front of the bucket are pressed against inclined rubbers, and thus cant the bucket over upon the flap of the apron. Two discharging levels are provided, and the tappets, rubbers, cams, aprons, and flaps are arranged accordingly. The valves which regulate the motion of the piston are not shown in the diagram. They are planted upon the ground level, and motion is transmitted to them by that of tne bucket through the agency of levers and cranks, and a stiff grooved rod passing down from the top to the bottom of the well. The lifting and lowering valves are mitred and balanced, and are reversed by a small hydraulic cylinder, the valve of which is acted upon by tappets. In order to bring up the speed of the bucket more gradually at the extremes of the stroke, throttle valves are introduced, which are also acted upon by a lever attached to the vertical grooved rod. A valve for governing the extreme speed is placed in the pressure pipe leading to the machine. The engine is started, stopped, and regulated by an ordinary stop valve, and a small pipe and cock is attached to the cylinder whereby the attendant can work the bucket up and down when required, independently of the working valves. It will be seen that when the bucket is up all essential working parts are out of the water, and therefore quite free of access.

The minimum lift at the high level discharge is 7 ft. and the maximum 23 ft., and about 5 ft. more stroke is required for tipping up the bucket. The usual average speed of the bucket in plunging or lifting is about 3 ft. per sec. The filling is effected in 5 secs., but the emptying occupies from about 12 to 15 secs. owing to a contraction that had to be made in the front end of the bucket to suit the existing masonry in the well. This latter operation with a free mouth to the bucket should not take more, if so much time as the filling.

The coefficient of effect obtained by this engine is as follows: At 7 ft. (minimum) lift .4; at 23 ft. (minimum) lift .6; average .54; which will be found to compare not unfavorably with other appliances under the same conditions of working, but the loss occasioned by the choking of passages and gagging of valves or paddles is altogether avoided by this system, which, for this reason, is peculiarly well adapted for sewerage purposes.

Mr. R. B. Grantham was of opinion that this system would work admirably for sewerage purposes. The existing bucket or plunger pumps were liable to be choked by the hair and other impediments common to sewage, and injured by gravel and sand.

Mr. Bramwell was doubtful whether this was the best implement for lifting sewage. For short lifts he thought it would not be economical, and for very high lifts it was manifestly inapplicaple. But where there was a lift of about 20 ft., and the sewage had to be delivered on the spot, then he thought the plan would be

useful. He wished to know whether the tipping arrangement was automatic, so as not to be interfered with by changes of level. Also why it was preferred to tip rather than to take in the water by a bottom valve.

Mr. Westmacott said that the arrangement was automatic. The valve was not used, simply because it was not thought desirable to employ anything that might be liable to obstruction. The bucket always caused a scour, and so kept the well clear. He thought there would be no difficulty in making a 40 ft. lift. Beyond that height there might be two or more buckets, each above the other.

HENDERSON'S PATENT PROCESS FOR REFINING CAST IRON.

In the November number of this MAGAZINE is an article on Mr. James Henderson's new process for the production of wrought iron and steel. It was then stated that interesting experiments had been made with fluorspar and hematites, for refining cast-iron, which we have now the pleasure of giving to our readers. The new patent process supplies a more effective and economical process than the English finery, or the German reverberatory furnace processes for refining cast-iron. It is very simple, and does not require any fuel, labor, or expensive apparatus; and there is no loss of weight of iron, as the impurities go off in vapor. The cost of refining is less than one-twentieth of that of the English and German processes; and its effect is more thorough than is possible by those systems.

The agents used are fluorine and oxygen combined. The fluorine is derived from any fluoride, and the oxygen from any substance containing or capable of evolving oxygen, which is adapted to use in the manufacture of wrought iron and steel. Fluorspar and pure rich iron ores are the most available and the most economical substances of producing these agents, and are applied finely powdered, and mixed, and placed in receptacles preferably, so as to act from the under side upwards upon cast-iron in its molten state.

The most economical mode of application of this process is to treat the cast-iron in the condition in which it flows from the blast furnace, with fluorspar and iron ore, applied in the "chills" or pig moulds, used at blast furnaces, by being spread over the bottom of the moulds. The iron when tapped from the blast furnace flows into the moulds thus prepared; he heat of the iron melts the fluorspar, and by reason of the affinities of these substances for silicon and phosphorus, these impurities are removed, in the form of *vapor*. The reactions in the "chills" are similar to those of the boiling puddling process, and last about five minutes. The metal during this period is covered with jets of flame and smoke. The resulting metal with respect to silicon and phosphorus, is as pure as wrought iron.

It is preferable to use iron ores containing the largest amount of oxygen and the least silica and phosphorus; these conditions exist in the "washed" iron sands of Canada and Long Island, and the specular and hematite ores of Lake Superior. When using the ores of Lake Superior, varieties that are the easiest to reduce to powder are preferred; and the ordinary edge running apparatus, with cast iron rollers, revolving in a pan, is an excellent one for the purpose. The fluorspar and fine ore are passed through a sieve of not less than 400 meshes to the sq. in., and afterwards mixed so thoroughly as to appear to be one substance, in the proportion of 1 part of fluorspar to 2 parts by weight of iron ore, and spread $\frac{1}{4}$ to $\frac{3}{8}$ of an inch deep over the "chills;" then the iron is run upon them so as to form slabs 1 in. thick.

The article in our November number described refined cast iron produced in the reverberatory furnace. It will be seen by comparing the analysis of the refined metal of this process with the analysis of that of the reverberatory furnace process, that they are analogous, except that the latter contains no silicates nor graphite. The refined metal of the pig mould process saves the fuel and time taken for refining by the reverberatory furnace process and shortens the time of producing steel or wrought iron by that process fully 40 minutes. When using the refined metal

of this process two workmen can take charge of 5 ordinary boiling puddling furnaces making steel, and 6 furnaces making wrought iron; as the only labor necessary is "balling" the metal and removing it from the furnace. When highly carbonized steel is made, "balling" is not required, as the metal will be fluid enough to run from the furnace into ingot moulds. The economy of the process consists in the saving of the labor of 8 workmen making steel, and 10 workmen making wrought iron; and in the superior quality of the result, as compared with puddling the refined metal. The time occupied by the conversion of the refined metal into steel and wrought iron by the process without puddling is about the same as that usually taken in puddling pig iron.

Ordinary coke pig iron, smelted near Pittsburg, from a mixture of hematite ore and mill cinder, has been treated by this process. The refined iron was afterwards puddled, and once heated and rolled into merchant bar iron. The pig, refined cast, and wrought iron have been analyzed by Mr. W. M. Habirshaw, analytical chemist, of this city. These analyses are annexed, also analyses of refined cast-iron, by the English finery and German reverberatory furnace processes, and of the highest standard qualities of English, French, Swedish, and Russian wrought iron, taken fron "Percy's Metallurgy" and "Ure's Dictionary," are given for comparison.

	Coke Pig Iron.	Patent refined Cast Iron.	Bar Iron.
Carbon (combined.)	0.2040	0.3613	.....
Carbon (graphite)	2 7685	2.5066	.....
Silicon	2.5096	None.	None.
Slags (Silicates)	0 3623	0 2983	.....
Phosphorus.	0 4196	0 1029	0.0087
Sulphur.	0.1298	0.1269	0.0438

	English Finery Process.	German Reverberatory Furnace Process.	
	Refined Cast Iron.	Pig Iron.	Refined Cast Iron.
Carbon	3.07	.....	.....
Silicon.	0.63	4.66	0 62
Phosphorus	0.73	0.56	0.50
Sulphur.	0.16	0.04	0.03
Silica, Alumina } Slags	0.44		

Analyses of Wrought Iron.

	English.	French.	Swedish.	Russian.
	Low Moor.	Petin, Gaudet & Co.	Hoop L.	C C N D.
Carbon.	0.016	0.143	0.087	0.272
Silicon	0.122	.....	0.115	0.062
Sulphur	0.104	0 058	0 220	0.234
Phosphorus.	0.106	0.030	0.034	.....

On comparing the analysis of the refined cast-iron of the patent process with those of the English and German processes, it will be seen that while the refined iron of the new process contains *no silicon*, that of the English and German processes contains 0.63 and 0.62 per cent. respectively; and, compared as regards phosphorus, the German process reduces it from 0.56 to 0.50 per cent., or about 0.06 per cent., and the new process reduces it 0.32 per cent., or over 5 times as much

phosphorus is removed by the new process as by the other processes. The slags or silicates are 0.15 per cent. less than in the refined iron of the English finery process.

The analyses of the patent refined cast-iron, compared with that of the English wrought-iron, show that whilst the wrought-iron contains 0.122 per cent. of silicon, the refined metal contains none; and compared as regards phosphorus, they are about the same.

The analyses of the puddled wrought-iron made from the refined cast-iron by once heating and rolling the "muck" bar, shows a purer quality of iron than the most celebrated brands of Europe, produced from the purest ores, with charcoal. The economy of the refined metal in saving cost of labor, fuel, etc., for the puddling process, has been fully demonstrated by numerous trials. When all of the advantages of the process are realized, about one-half of the cost of converting cast-iron into wrought-iron can be saved; and there is an improvement in the quality equal to the difference between ordinary forge pig-iron and charcoal iron.

These advantages are:

First.—Better quality, which is due to the purity of the refined metal; as good qualities are produced from it as from pig-iron made from the best ores smelted with charcoal.

Second.—The refined metal, being as pure as wrought-iron, with respect to silicon and phosphorus, requires merely decarbonizing, with less skill to work it, and greater certainty of the quality of the product.

Third.—Large saving in the cost of production, owing to the shortening of the time of puddling, which is caused by the removal of a large part of the impurities by the refining process. White refined iron is decarbonized in 12 to 15 min., and a "heat" or charge of 500 lbs. is puddled in 55 min., including time of charging, melting the iron, and stirring or puddling and "balling" and removing it from the furnace; gray forge iron requires 65 min., and foundry iron about 70 min. Seven "heats" or charges to a "turn," or a day's labor, are of easier accomplishment than five charges are from the pig-iron from which it was produced; the five charges now require about 10 hours to convert pig-iron into wrought-iron. It is possible to obtain with the patent refined metal, by employing three sets of workmen for the 24 hours instead of two sets as is now customary, twenty-one charges in 24 hours instead of ten charges; and allowing sufficient time for repairs, the production of any iron works may be doubled, without additional investment of capital and without additional cost of repairs.

Fourth.—Saving of fuel per ton of iron produced, amounting to one-half, caused by increased production.

Fifth.—Reduction of general business expenses per ton of iron, amounting to one-half, caused by increased production.

Sixth.—Reduction of wages by reason of the diminished labor (of about 40 per cent.) per ton of iron.

Seventh.—The puddling furnace cinders of the refined metal contain but about one-fourth of the phosphorus, as compared with the cinders resulting from the use of pig-iron; and, when smelted, produce better qualities of pig-iron.

The cost of refining in the pig moulds is very little. Fluorspar is a cheap material, and but about 70 lbs. are required to refine a ton of iron. In some localities the cost will be compensated by the saving of the fuel and lime which would be required to reduce the puddle cinders of the refined cast-iron to pig-iron, as they contain no silica, and will require less fuel and limestone. The residue of the fluorspar and oxide (when iron ore is used), after being used in the process, is agglutinated and remains in the pig moulds, and is pure lime and deoxidized iron ore, and is available as so much ore and lime in the blast furnace.

THE following is a simple method for detecting the presence of wood fibres in paper or fabrics. The reagent employed is a weak aqueous solution of sulphate of aniline. If a drop of this liquid, on a pointed glass rod, be applied to paper, if wood be present, even in minute quantity, an intense yellow color will be immediately visible; but the test is only applicable when the wood pulp has been prepared in a mechanical way. Chemically prepared wood does not yield the same reaction.

BETON Coignet is being extensively manufactured in Brooklyn, N. Y.

THE BUBBLING AND SCINTILLATION OF IRON.

Translated Abstract from "Comptes Rendues."

The writer has shown, in a previous article, that steel and cast-iron do not boil or scintillate, if they are melted in an atmosphere of hydrogen or carbonic acid, so that the phenomena of the metal when melted and poured cannot be attributed to the escape of a reducing gas taken up during the melting. It is his opinion that the bubbling and crackling is caused by a reaction of oxide of iron upon the carbonic compounds. In support of this view the following is offered:

Iron or steel, in the crucible, is heated for a long time before melting; it is covered with an oxidized layer, and within this there is a thin layer of carbonized steel; the interior remains unchanged. When the inner portion is melted it breaks through the resisting envelope; the crucible is filled with melted steel containing the external envelopes. These react upon the carbon of the iron or steel, and cause the generation of carbonic acid gas.

Another cause of the formation of this gas must not be left out of sight. If the metal is thoroughly melted, when the crucible is opened air enters; the stream flowing into the mould is oxidized at the expense of the air, and a mixture of oxide and iron, containing carbonic acid, with air, is introduced into the mass; these continue in a condition of mutual reaction until solidification, and possibly longer.

The scintillation of iron, when heated in oxygen, has been attributed by the writer to escape of a gas previously absorbed. Experiments have confirmed this theory, but at the same time have suggested an additional cause.

Pure iron and common forge iron do not crackle, if melted in a well-closed earthen crucible, or in a porcelain tube, in an atmosphere of hydrogen or carbonic acid gas. The phenomena seem to be different, if the same iron is placed in a shallow vessel of lime, and submitted to the direct flame. If care is taken to furnish the flame with an excess of hydrogen, the iron is, for the most part, oxidized in mass, while it is melting; and if, after thorough melting, the flame is removed, a lively scintillation and bubbling is often the consequence.

The following experiment was made: A shell of lime was filled with pure oxide of iron, pressed into small cylinders; a cover was put over these, and they were melted by the blowpipe, so as to assure a maximum excess of hydrogen in the flame. As soon as the mass was melted the flame was removed, but the cover was not removed. The mass stiffened on the surface; this rose, and finally, after cooling, crackled, without emitting sparks. If the mass was kept too long in a melted condition, the crackling did not occur; probably because the oxide and the lime had combined. A little silicious acid also prevented this phenomenon.

The same effects occurred when the melting vessel was made of magnesia or of pure protoxide of iron compressed.

Notwithstanding the excess of hydrogen in the flame, reduction of the oxide to metallic iron never ensued. Indeed, since the experiments of Magnus it has been settled that hydrogen in the presence of steam never reduces the oxide of iron at any temperature. It follows that bubbling and crackling of iron melted in a lime vessel is caused by a gas which is absorbed by the oxide contained in the flux.

The melting of pure iron in a current of hydrogen is difficult, as the porcelain tubes generally soften before the metal is melted; but the Schlösing blow-pipe may be used. Experiments were made with quantities.

If the iron was entirely melted it remained free from bubbles, showing that the hydrogen was not absorbed by the melted metal. Besides, the specific gravity of bars not hammered was increased, showing that the density of iron melted in a current of hydrogen is greater than when it is melted in an atmosphere not reducing. Iron melted in a hydrogen current, containing no trace of carbon was found to be easily wrought when in a red-hot condition without the usual precautions. It approaches copper in softness and ductility, and is ductile when cold. Forge iron melted in the crucible is, on the contrary, considerably harder. The large and shining facettes on its surface of fracture are like those of iron

subjected to continuous vibrations. At red heat it is with difficulty drawn into wire, and to forge it easily it must be subjected to long welding heat; but it never hammers as well as the iron prepared as above. While hardening in the crucible it experiences an obvious contraction, so that a cavity is often formed within; a circumstance likely to lead to incorrect calculations of specific gravity. A bar of the latter iron cut into thin laminæ yields, under continued heat in hydrogen, a considerable quantity of water, and after cooling there is a decrease in weight, mostly due to the removal of oxygen originally contained in the metal. In some cases the diminution was 0.5 per cent.

ON THE CONSTRUCTION OF SEWERS IN RUNNING SAND.*

By T. MELLARD READE, C. E.

From "The Building News."

All who have had experience in engineering are aware that the most valuable knowledge is often that acquired while contending with unforeseen difficulties. The introduction of the present subject to the notice of the British Association will, therefore, we hope, require no apology beyond the simple statement that some of the sewerage works intrusted to us having been executed in difficult sandy ground, we are desirous of recording, for the use of others, some of the experience necessarily obtained.

Probably no one who has not watched the process of laying sewers in ground similar to that which distinguishes the land on the Liverpool, Crosby, and Southport Railway, the whole distance from Waterloo to Southport, can form any idea of the difficulties that have to be encountered. The whole of that district is one mass of sand resting on a bed of moss and marl, varying from 10 ft. to 20 ft. deep below the surface, and, having no natural drainage (in consequence of the elevation of the shore line of sand hills) in wet seasons in the lower portions or slacks, flashes of water form.

The permanent water level in the driest seasons in these places is only a few feet below the surface, while, sink where you will, before you get to the depth necessary for a sewer you are sure to come to water. Now, water in gravel or rock is not difficult to contend against, but in fine-blown sand it forms a subsoil of running sand or quicksand of the most lively and insinuating description.

Sheet pile or trench as you may, it reams in between the sheeting in streams of sand, and also forces itself bodily upwards in the bottom of the trench by a species of disguised hydrostatic pressure. To keep open more than a short length of trench the full depth during the laying of the pipes is impossible, and consequently the difficulty of laying the invert of the sewer to a true gradient is immensely increased, while the low gradients demanded by the general flatness of the country require for the efficiency of the sewer extreme accuracy.

When practical, in order to relieve the ground of water, it is advisable, we find, when it can be done without timbering, to open out a long length of cutting about 5 ft. or 6 ft. deep beyond where the pipes are actually being laid. In our works, from motives of economy and other reasons, we have mostly used pipe sewers socketed, glazed, and jointed in fine cement. Theoretically, such pipes with cement joints should form impervious sewers, but they do not; with the ordinary system of laying, we know this to be impossible. The consequence is, that where you have several miles of pipes, the subsoil water that enters the sewers is enormous. Summer or winter the flow is unceasing, nor is this in itself a disadvantage, but rather the contrary, for the tendency of the flow is to keep the sewer sweet and clean. The Blundellsands main, which, with subsidiary drains, is about 2½ miles long, in dry frosty weather last winter when gauged showed a discharge of 180 gallons per minute, ¾ of which at least would be subsoil water; and, apparently, except during rain, the flow does not materially differ at various seasons. This, then, as far as the water is con-

*Paper read before the Mechanical Section of the British Association, at Liverpool.

cerned, is a distinct advantage, but along with the water sand reams in and forms a deposit along the whole length of the sewer, which is only removed by frequent flushing. In every case where pipes are laid in running sand, however well and carefully the joints are made, we find this to occur. To get the cement to set before being washed into the sewer is no easy matter. In laying the pipes about 20 yards of timbered trench is opened at one time. A dam of sods, etc., is then formed across it in front of the pipes, and the sand between it and the pipes is dug out until a hole is formed, from which the water can be baled out into the trench above, from which it is pumped to the surface. When all is prepared, the pipes are lowered down into the trench one by one, the joints being laid on a bed of clay puddle 6 in. thick ; the joints are then made good with quick-setting cement, and the cement is covered all round with a good collar of clay puddle to prevent it being washed into the sewer. With very great care and judgment a good sewer may thus be formed, but not a water-tight one, and we always find that the subsoil is drained nearly to the invert in the very best and most carefully constructed sewer we have yet seen. This is a positive advantage, but the consequent admission of running sand—and it is astonishing how fine an opening it will ream through—is an evil which it would be well, if possible, to guard against. In addition to this, the sinking of the baling-out hole while laying the pipes has a tendency to draw the end pipes downwards, and thus interfere with the true gradient of the sewers. In all sewers in ground of this nature, we have also to form what is called a sumphole at the bottom of each manhole, or they would speedily get choked. By the aid of the flushing apparatus, which we shall presently describe, the deposit in the sewers is flushed into these sumpholes and then cleaned out at intervals. It is difficult to convey to any one who has not seen it the insinuating nature of this sand, but by attention and frequent flushing we find that well-laid pipe sewers in such ground can be kept clean and sweet.

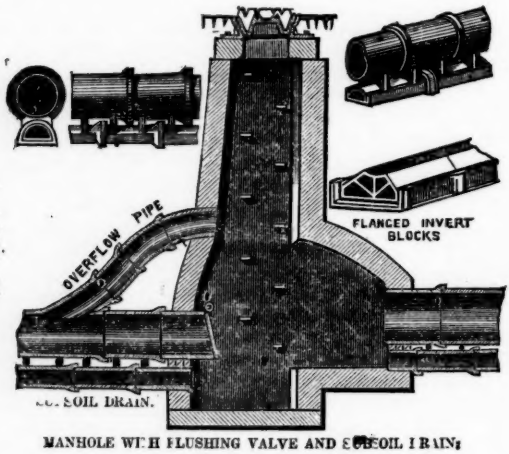
Though sewers are possible and effective laid in the manner just described, it is a matter of much care and attention to get them laid properly, and it is really essential that a clerk of the works should himself see every individual pipe laid. With all this, still imperfect joints occur, for as soon as the baling out ceases as the pipes are practically plugged up with a straw plug which is drawn through the sewer to keep it clean, the level of the water rises sometimes even above the top of the pipes, and the hydraulic pressure thus created will find out all imperfections and sometimes prevent the cement setting properly. Again in putting in the sumpholes the tendency is to draw the nearest pipes out of the level, and indeed the most satisfactory way of getting them in is to sheet pile them all round. Having had all these manifold difficulties to encounter, we set ourselves to try and devise some method by which greater care in and perfection of laying could be obtained.

The model of the subsoil drain and pipe-rest we now have the honor of showing you is partially the result of our experience in laying sewers in sand. At our suggestion Messrs. Brooke & Son, of Huddersfield, the fire-clay pipe manufacturers, have worked out the invention in a practical form, and we are now commencing to use it in the sewerage works at Birkdale. The primary object of attainment in this is to get a dry subsoil wherein to lay the pipes that the cement joints may have time to set and become water-tight, and by securing more time for the laying of the pipes, laying a greater length at a time, and the prevention of disturbance or drawing of the pipes while preparing the next excavations, to insure greater certainty and perfection in the gradients and junctions, and consequently the general system of pipe sewerage. That this is of the utmost importance none who practically understand the subject can doubt, for the difference between brick sewers and pipes often means whether sanitary work shall go on or be stopped.

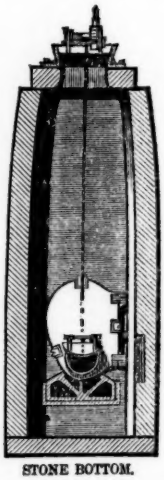
The subsoil drain, it will be seen by an inspection of the model, is an internal section, a semicircle, and varies in diameter according to the diameter of the superimposed sewers. For 2 ft. pipes we purpose using drains 1 ft. diameter ; for 1 ft. 6 in., 9 in. diameter ; and for 1 ft., 6 in. diameter. The length is the same as the pipes in the sewer, *i. e.*, either 2 or 3 ft., as the case may be. The larger pipes we use in 3 ft. lengths. Each pipe is socketed, and the sides being brought up

square, a shoulder is formed on which the movable bricks forming the rests (which also fit the top of the drains and the curvature of the pipes) are laid. The pipes in the sewer above are arranged so that they break joint with the subsoil drains, and the ends of each sewer pipe rest on the adjoining subsoil pipes. It will be seen that this arrangement secures ample space under the sewer for making the cement joints good.

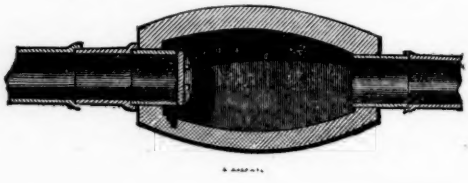
The operation of laying the subsoil drains is somewhat similar to that previously described as the mode we adopted for laying pipe sewers before employing this invention, the only difference being that the joints are made in clay alone, and from the small size of the pipes they can be handled and laid much more readily; slight imperfections in the gradients also will not be of the same consequence as in the sewers. When a sufficient length is

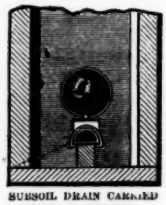


MANHOLE WITH FLUSHING VALVE AND SUBSOIL DRAIN.



STONE BOTTOM.

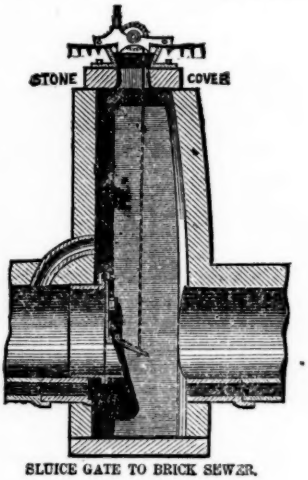




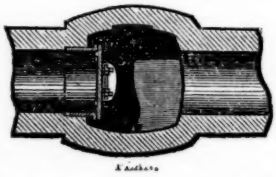
SUBSOIL DRAIN CARRIED THROUGH MANHOLE.

opened out, we commence laying the sewer pipes upon the brick saddles or rests, which have previously been accurately laid to the proper levels from sight rails in the usual manner. As this can be done without hurry or confusion, a more perfect sewer is the result. The subsoil drains are continued through some of the manholes, as shown in the engraving, and are united to the main sewer at intervals, discharging their contents into sumpholes which retain the sand that may be brought down by the water and which then can be readily cleaned out when necessary. In each of the intermediate manholes, where the subsoil drains are carried through, they will be fitted with a disc plug on the top for the purpose of flushing. When the flushing valves (to be hereafter described) are down, the removal of any of these disc-plugs will allow of any portion of the drain being flushed with a good head of water. It will thus be seen that while we retain all the advantage of subsoil water, we avoid the evils of running sand, which, if not attended to, accumulates in the bottom of a sewer, cakes with the sewage matter, and

obstructs the flow. Perhaps some may think that it would be better to keep the flow of subsoil water entirely separate from the sewage by continuing the drains through or round all the manholes, with provision for admitting the subsoil water into the sewers whenever required for flushing. Special cases undoubtedly require special treatment, and in the case of wet gravelly ground it may sometimes be an advantage when using the subsoil



SLUICE GATE TO BRICK SEWER.



drains, to carry out a separate system; but in running sand the case is different; for without a certain number of sump-holes the drains would infallibly get choked, and to fit the subsoil drains with separate manholes and sump holes would unnecessarily complicate the sewerage works, besides introducing other evils. As a rule, we are in favor of introducing subsoil water into sewers, as a constant flow tends to sanitary efficiency; but where the sewage is to be used for irrigation it may in some cases render it difficult to dispose of the whole of the sewage, especially where pumping has to be resorted to. There are, however, to our minds so many objections to a separate system that we should not adopt one except for very special reasons. None can lay down rules and formulæ for inflexible guidings in engineering matters; all that can be done is to state principles, and the intelligence of the engineer must be his guide in their application. Though primarily the object sought in the invention of the subsoil drain and pipe rest was the more perfect construction of the sewer proper, it possesses the additional merit of reducing the permanent level of the subsoil water to a lower level than does the ordinary sewer, and is a distinct provision for that object, instead of an accidental accompaniment of sewerage works.

Brick sewers it is common to construct with invert blocks when the subsoil is wet, and they make a very true foundation to build the sewer upon. In running sand we find it very much better to construct the inverts with flanges as shown, and to bed them in clay as a precautionary measure for keeping the sand out of the sewer. After the sewer is completed it is unnecessary to keep the invert drain open, as the brick sewer being porous admits the subsoil water and effectually drains the ground. During the construction of the sewer the invert blocks act as subsoil drains, and very much facilitate the work. The experiments we have already made with the subsoil drains have thoroughly satisfied us as to their efficiency. We find that when they are laid the sewer can be constructed with extreme facility with perfect joints, and that the effect of the sewer-pipes breaking joint with the sub-drains is not only to strengthen the sewer at the joints and prevent drawing, but to insure perfection in the gradients. The subsoil drains are, in fact, a foundation for the pipes of the sewer, and the sewer itself can be as readily constructed upon them as if the ground were perfectly dry. Those who have had experience in running sand will see that this is no small advantage, independently of the draining of the subsoil which will necessarily occur. We have begun to use the subsoil drains or "blocks," as the workmen call them, in the sewerage works we are carrying out at Birkdale, and when by their aid we get the 10,000 yards of intended pipe sewers completed, we shall

be in a position to state the results, and to give further information to any engineers who may ask for it.

For all sewers, flushing is of the utmost importance ; yet how seldom is any provision made for it except by the introduction of a water company's hose, which combines the minimum of effect with the maximum expenditure of water ? In all our works we introduce flushing valves of the forms shown in the engraving, but for sewers in sandy districts they should be used at more frequent intervals, for unless we have an abundance of scouring force we are never safe as to the permanence of the sewer. Frequent flushing is of the utmost importance ; it is of no use making elaborate provisions that cannot be used when most wanted, or letting apparatus rust for want of efficiency in the executive. Local boards too often think they have done everything when a sewerage system has been carried out ; that it should be constantly attended to is of almost equal importance. No apparatus can dispense with intelligent supervision, but we cannot speak too strongly on this point, for, although it is a truism, local authorities act as if everything were self-acting, and only examine a sewer when it is time to pull it up. Unfortunately, engineers are partly responsible for this state of things, for their works formerly were, from the absence of provision for flushing, apparently constructed on the same supposition. Flushing gates for large sewers are frequently used, but we are not aware of valves being used by others than ourselves for flushing pipes with their own waters. That all sewers should be flushed with their own waters should be an axiom of engineering, for otherwise in drought, when water is scarce, and the deleterious decomposing matters which invariably accumulate in the best constructed tributary sewers most require removing, they stand a good chance of being left to breed fevers and other diseases. By having the valve, consisting of a cylindrical barrel, of the diameter of the pipe it is connected with, built into the manhole, and fitted with a flap valve hung to a diagonal face with a brass pin in the hinge, the water accumulates up the sewer until it rises to the safety overflow, which should be below the level of any adjoining cellars. When this occurs, sufficient hydraulic power is accumulated to sweep all deposits out of the sewer below to the next valve. It must be understood that the sewer above the valve for a certain distance also shares in the cleansing operation ; but the force is greatest near the valve, and it decreases until it reaches a distance sufficient for the whole of the water to get into "tram," when the scouring force is equalized, though much diminished. We have used these valves in all our works for the last five years, and find them invaluable. They, in fact, render that possible which would otherwise be impossible. We use them up to 2 ft. diameter, but for the larger sizes a small portable crab winch, shown also in the engraving, capable of lifting one ton, and which fits on the manhole cover, and to the barrel of which the chain of the valve is temporarily attached, is employed to lift them. For brick sewers and sewers of a larger diameter, the flushing-gate manufactured by Mr. Samuel Harrison, of Soho Foundry, Liverpool, is used. When not in use it lies back against the side of the manhole, and is held in its place by a catch. When closed and screwed up by the handscrews, the water accumulates behind and keeps it tight against its face until reaching the overflow. On to this gate is fixed a circular valve near the invert of the sewer, precisely similar to that described for the pipes, and when it is required to flush the sewer it is suddenly lifted, a rush of water takes place along the invert and sweeps all before it. When all has escaped, the gate can be thrown back readily, as it is relieved from all pressure. The flow of water being directed to the invert is more effectual than it would be were the gate itself opened, and the flushing force being applied through a smaller orifice lasts longer and is more sustained. The great advantage, however, is that a very large sewer can thus be flushed without any of the mechanical aids necessary for opening a large flushing gate against pressure, and consequently the cost of the gate is not half that of the ordinary sluice. At the termination of all the sewers we provide a flushing-box and pipe for filling the upper part of the sewer above the first valve, as the natural flow is there, of course, only small. The gullies we use are easily cleaned of sand, and have the advantage of remaing trapped during great drought, as 5 in. of water must evaporate before the untrapping takes place.

The form of ventilator also manufactured by Mr. Harrison, of Liverpool, though applicable to all situations, is especially so for districts where either much loose sand is blown about, or where there is a heavy traffic and consequently muddy roads. The ordinary form, consisting of a brick chamber and separate ventilating grid, under such circumstances soon gets choked with mud or sand, and the consequent damp also destroys the efficiency of the charcoal. In all sanitary works, as we before said, we must have efficient superintendence, and the best method of making that superintendence efficient is to make the work easy and light. It will be seen that the ventilator consists of a combined manhole and ventilating cover. The air grid is in the manhole cover itself, the frame which it fits into being lengthened into an air shaft which is perforated at the side, and the bottom is sealed with the movable mud basket, to prevent any passage of air from inside to outside except through the deodorizing charcoal basket. It will be seen that during a heavy fall of rain, or should the cover accidentally be fixed lower than the road and surface water enter, the water may overflow the mud basket. To avoid damping the charcoal, this is provided for by the overflow pipe, which is carried down into the water of the sump-hole, which traps it and prevents it becoming a channel of communication between the internal gases and the external air. A small brick chamber or flue is built at the side, covered with a cast-iron plate to receive the paving. The mouth of this in the manhole is fitted with an iron frame to receive the charcoal basket, and the upper part communicating with the perforations in the side of the shaft of manhole cover, and thence with the external air. It is evident from this arrangement that the mud basket can be readily lifted out by its handles and emptied of its contents, and also that no inspection of the sewer can take place without this preliminary operation being guaranteed. We have now described pretty fully our arrangements for sewering wet sandy ground. Many of these inventions we use also in other places, but the original suggestions for them have arisen from our contentions with sand. In other subsoils, with quick gradients, we only use sump-holes in those manholes where the valves are fixed, carrying the sewer through the intermediate manholes by open culverts, constructed in brick, of the form of the sewer, and in fact forming the bottom of the manhole, with a shoulder on each side. Undoubtedly the most efficient system of sewerage is that which sweeps all matter away at once to the outlet, and sump-holes should only be used to prevent the possible choking of the sewers. The conditions of perfect sewerage may be summed up thus: True gradients, as quick as can be obtained, but increasing gradually from the outlet to the branch sewers; perfect construction; requisite depth below the surface; provision for draining the subsoil water to the level of the sewers; adequate flow of water in the sewers; abundance of flushing power; constant flushing and sufficient ventilation; and real active supervision in the executive. But above and beyond that, the abolition of cesspools, middens and stagnant pools, together with a perfect house drainage, are essential. Often when sewerage works are completed the whole of their utility in a sanitary point of view is vitiated by criminal neglect of the house drainage. It is not merely sufficient to connect existing drains or the overflows of cesspools with the sewers; they should be thoroughly examined, abolished, and the drainage reconstructed where necessary. We have no doubt that defective house drainage is in most cases responsible for local outbreaks of fever and other diseases, rather than the main sewers. We have not treated of the ultimate disposal of sewage, as that is not within the scope of this paper, but may say that we firmly believe irrigation to be the only absolute remedy, and that in time works for effecting it will be considered an integral portion of any sewerage system. That time has not yet arrived, but we are rapidly approaching it, and we wish the movement "God-speed." To consider sewerage complete when the sewage is only turned into a river, or on to a shore, is a barbarity unworthy of the age, and it is the duty of Government, and also we hope its intention, to absolutely prohibit the fouling of the watercourses and shores, and so force the question on to its only logical conclusion.

During the siege of Strasbourg the cannon were heard at Baden, 15 miles distant

BLASTING ON THE UNION PACIFIC RAILROAD.*

The cut was through dark blue limestone which had been partially taken out so that there was left in it a mass about 100 ft. long and 18 ft. deep, with the ends well squared up. The average width thrown out being 24½ ft., the total amount was 1, 633 cubic yards.

The original depth of the cut was 31 ft., of which 13 ft. had been removed.

The powder was put in 2 wells, 34 and 20 ft. respectively from the 2 faces, leaving about 46 ft. between the 2 blasts.

The first well was sunk vertically to grade (18 ft.), two chambers were then excavated along the axis of the cut each 6 ft. in length. The second well, also 18 ft. in depth, had a slant of about 10 deg. towards the first well, with a chamber in the same direction about 4 ft. long.

The wells, which were as small as it was possible for a man to work in, were blasted with nitroglycerine. The first with 2 chambers, required 9 eight hour shifts of 2 men each, and 15 lbs. of nitro-glycerine.

Cost of 1st well.

Labor 18 days at $3.....	$54 00
Nitro-glycerine, 15 lbs. at $2.....	30 00
	$84 00

The second well with 1 chamber required 6½ eight hour shifts of 2 men each, and 11 lbs. of nitro-glycerine.

Cost of 2nd well.

Labor 13 days at $3.....	$39 00
Nitro-glycerine, lbs. at $2.....	22 00
	$61 00

The first well was loaded with 78 and the second with 33 kegs of powder, 111 kegs in all, which at 25 lbs. per keg is 2, 775 lbs. or about $1\frac{7}{10}$ lbs. per cubic yard. This large amount of powder was used on account of the rock being at the bottom of the cut, and firmly bound by its sides. Also from the nearness of the track, which made it desirable to throw as much material out of the cut as possible, to save time.

The powder was first covered with logs firmly wedged into the wells, and then tamped with fragments of stone well rammed in layers. Three fuzes were used for each charge, cut carefully of the same length. The blasts were successful, exploding within a few seconds of each other. Only about 600 cubic yards of material were left in the cut, which were removed by 6 eight hour shifts of 18 men each.

Cost of blasting and removing 1,633 cubic yards of rock.

1st well.....	$84 00
2d "	61 00
111 kegs of powder at $10.....	1,110 00
120 ft. of fuze at 3 cents.....	3 60
Logs, loading, etc., about....	25 00
Loading material left in cut into carts, 18 men 6 days at $3	324 00
	$1,607 60

Or less than $1 per cubic yard. To which is to be added for superintendence, carting, etc., about 10 per cent,, making a total of $1.10 per cubic yard.

*A paper read by E. P. North, Civil Engineer, before the Am. Society of Civil Engineers.

REPORT ON THE SUEZ CANAL.

By T. LOGAN, C. E., Executive Engineer.

From "The Artizan."

In continuation of my report on Irrigation in Egypt, now submitted, and in accordance with a letter dated November, 1869, from the Home Government, I have the honor to forward a report on my late inspection of the Suez Canal, which, through the kindness of the Canal authorities, I was enabled to do, in a satisfactory manner.

On my first visit to Egypt, in 1856, I could not help observing that, though the harbor of Alexandria is close to the most western mouth of the Nile, yet during these last 3,000 years or so, no perceptible change in the depth of the harbor has been observed, so far as I could learn; and on my return voyage, I made particular inquiries on the subject, which led me to the conclusion that the current which enters the Mediterranean at Gibraltar, passing along the north coast of Africa in an easterly direction, which ulti-

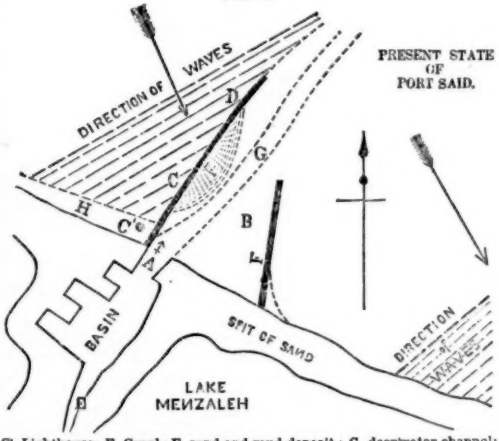
mately passes along the south coast of Europe, causing a considerable current through the straits of Messina, and ultimately returning to the Atlantic by an undercurrent through the straits of Gibraltar, must be one of the chief causes why there should be no deposit in the harbor of Alexandria, and that we should look for it along the coast east of the mouths of the Nile. So satisfied was I on this had to defer my visit till this present occasion on my return to India.

While in England, however, I had on two or three occasions read papers in connection with this question — the "abrading and transporting powers of water" — which, I believe, increases in some ratio as the velocity increases, and decreases as the depth increases; so I may now simply state that my late inspection confirms these views, and that I found that a considerable deposit has taken place, and is still going on.

I was informed by the engineer at Port Said, that it was during the fall of the year that deposits chiefly took place, that is, while the Nile is in flood, that the prevailing wind was northwesterly, but towards the afternoon it usually veered round to a northeasterly direction; but any one who has sailed in the Mediterranean knows that the winds are not constant like the "trade winds," or the monsoons, so, though the prevailing winds may be northwestern, it is by no means intended to affirm that there are never easterly gales along the coast. Now, if the wind is the sole cause of the transport of the Nile silt, it can only be by the waves breaking on the beach; and, if so, surely in these last 3,000 years some of this silt would find its way westward to Alexandria, and also the deposits at Port Said would vary more according to the winds rather than to the floods down the Nile; consequently, as these floods bring to the sea this earthy matter, and fresh water being lighter than that of the sea, the fresh water holding this in suspension floats on the salt water, and by this current in the Mediterranean is transported eastward, ultimately uniting with it, and depositing its load along the coast.

point that I made arrangements to remain in Egypt for a short time on my return home in 1867, so that I might visit Port Said, and see if there were not deposits taking place at that spot, for I considered the breakwater there must act in the same manner as spurs on our rivers in Upper India, and cause a deposit east and west of them. Sickness, however, prevented my being able to remain in Egypt, so I

FIG. 1.



C', Lighthouse; E, Canal; F, sand and mud deposit; G, deepwater channel; H, land reclaimed. The arrows point to prevailing winds.

By the accompanying sketch, Port Said, it will be observed, is on a narrow spit of sand which runs along the coast, commencing near the most eastern mouth of the Nile, and extending eastward for many miles further. Behind this spit there is the shallow lake Menzaleh, while on the northern face of it is the Mediterranean Sea.

The slope that the sea beach here takes is as near as possible 1 in 300;* the depths along the site of the present breakwater, previous to commencing work, varied from 1 to 6 miles.

The advance along the sea coast on the western side of the breakwater is considerable, as it extended along the beach

* The slope of a sea beach appears chiefly to depend on the nature of the materials it is composed of. Thus, at Madras, where the sand is very coarse, the slope seaward is comparatively steep, though exposed to a heavy surf; while at Weston-super-Mêr, on the Bristol Channel, where there is clay, the slope is barely 1 in 500, while where there is sand it is about 1 in 100. The Nile sand is not coarse, being much the same as the sand in Upper India. Where there are pebbles and boulders the slopes increase accordingly, varying according to the size and beat of the sea.

westward 540 metres in November, 1861, when it had only advanced 70 metres seaward.

The advance in—

June, 1851,	westward,	about	1,000	metres and	140	seawards.
May, 1855,	"	"	1,500	"	160	"
Nov., 1865,	"	"	1,800	"	225	"
Jan., 1867,	"	"	2,000	"	265	"
June, 1868,	"	"	2,200	"	320	"

From this it appears that the land which may be reclaimed already covers an area of little short of 100 acres, and as it protrudes out into the sea, before long this reclaimed land will become the favorite site for private residences, owing to the sea breeze, and the value of this property will no doubt hereafter go a considerable way to repay for any future extension there may be necessary for the breakwater.

The present advance seems to be at the 10 metre or 5½ fathoms depth—some 75 yards—yearly, while in the same period the sea has receded some 50 yards a year; but I do not anticipate that the advance will be so rapid in future years as it has been up to the present time; for, as the deposit extends seaward, so will it extend westward six or seven times as far: thus the area will increase over which there will be deposit in the same ratio as a triangle having its side in the proportion of one side perpendicular to six or seven horizontal.

On the west side of the breakwater, that is, the exposed side, I observed a very remarkable fact when examining the sections, namely, where the depth of the water exceeded three metres it was always deeper away from the breakwater than just at the side of it, but where the depth was less at the side than three metres it was shallower. There was a similar effect on the east or harbor side, and this probably arises from the beat of the sea on the breakwater agitating the water between the blocks and thereby preventing deposit in their vicinity.

Regarding the deposit on the east or harbor side, it is not such a serious matter as I feared, for so long as the silt only comes through between the blocks and not round the outer end of the breakwater, I do not anticipate much trouble, for in the former case the best plan is to leave it alone and keep the deep channel for ships well away from it.

At first this deep channel was 150 metres from the breakwater, but now it is 200 metres; I think it would be still better to have it removed 250 metres away from the breakwater up to the point where the sea reaches, but beyond this, and all the way inland, there can be no objection to dredging close up to the breakwater; for where the deposits on the west side of it are level with high water, it is evident there can no longer be a passage of silt through the breakwater; and as the blocks of Beton were in the first instance deposited in comparatively deep water there can be no danger of disturbing them; consequently a wharf along this portion could be constructed at little expense, for ships to lie alongside of it.

The deposit along the east side of the breakwater where it had silted up to high-water mark, appeared to be of much lighter consistency than on the other side; for while on the west or Nile side, the deposit was sand, on the east side there appeared to be a large admixture of mud, and the more inland the more did mud predominate.

The ship I passed through the Canal in was anchored about opposite the light-house at the point A in Fig. 1, and on heaving up the anchor, a quantity of Nile mud was attached to the chain. Now as this was in the line of the spit of sand before referred to, it appears that only fine mud is deposited at this spot, and as sand is the chief substance held in suspension by the waves beating on the shore, this I think convincingly proves that the water in the harbor opposite the Light-house cannot be much agitated. And as I could not observe any current in the canal, and the water was comparatively clear at the upper end of the Grand Basin, we may rest satisfied that there is no great danger of large deposits either in the canal itself or the basin, so what deposits take place will for the future be chiefly beyond the Light-house.

The important question now to consider is: Will this deposit be to such an extent as to endanger the navigation, and will the dredging here be so expensive as to make the canal an unprofitable undertaking in a financial point of view? To this would I beg to draw particular attention, for in my opinion the chief difficulty in working the canal and keeping an open channel lies between the Light-house and the open sea, all other difficulties from

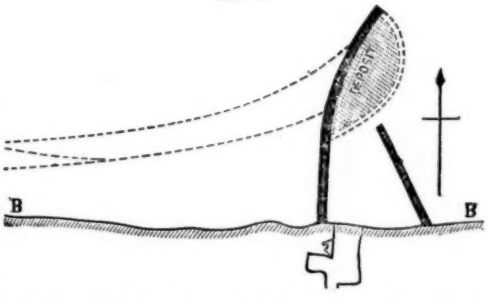
Port Said to the Red Sea being of secondary importance.

I have before said that the advance of the land seaward is about 75 yards a year at the bottom, and 50 yards at the surface, and the slope of the shore seaward is about 1 in 300. That is, to have six fathoms of water at the end of the breakwater, it must extend beyond the dry land portion about two miles ; and, allowing these two miles a deep channel, at least 100 yards wide will have to be kept open. The question is : Will not dredging out end of the breakwater on the western side for a short distance, and even a deep hole scooped out at the extreme end, yet the current will sweep round the point, and deposit the mud and sand along the east side, as shown in Fig. 2. And it will be no easy matter to keep a deep channel through this deposit, where the depth is 30 ft., and the Mediterranean is not always a tranquil sea to work in.

What I therefore venture to suggest for consideration, is to extend the present breakwater, not in a north-easterly direction, but in a north-westerly one, running it out, as a sailor would say, in the teeth of the prevalent wind, or at an angle of 45 degs. with the coast, and for every 3 ft. of additional length there would be about 2 ft. of "offing ;" thus any heavy material which may travel along the coast by the oblique action of the waves must come to rest, for it would have on reaching the breakwater to travel out to sea in the opposite direction to wind and waves, which is not likely to occur. By this modification it appears to me that there would be a great deposit all along the sea face of the Delta of the Nile, which in the course of centuries may affect the present geography of Egypt along the sea coast, but is a matter which may safely be left to the Duke of Suez's great-grand-children, to consider. Our present question is : Would this arrangement more perfectly stop the mud and sand brought down, by the Nile turning the end of the breakwater, and thus closing up the entrance to Port Said ?—and this I believe it would, though some silt would still find its way between the blocks of Beton, and even round the end of the breakwater. But this channel to a depth of five fathoms (30 ft.) be a very expensive operation, and is there no way by which this may be avoided?

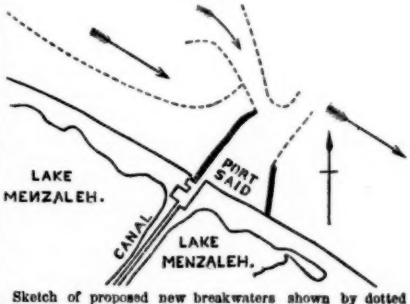
It has been proposed, I believe, to slightly change the direction of the breakwater hereafter, bending the outer portion in a more easterly direction, when it is supposed it will give a set to the current seaward, and deposit the silt in deep water. My experience of spurs on our river leads me to doubt this, and though there may be deep water along the outer

Fig. 2.



as this silt, as has been already said, is much finer or lighter than the land on the western side, it would be all the more easily affected by scour ; so that the question is : How is this scouring power to be obtained ? By another breakwater placed in a slanting direction, say at an angle of 60 deg. with the coast, a funnel-shaped channel would be obtained, as shown in No. 3.

Fig. 3.



Sketch of proposed new breakwaters shown by dotted lines. The arrows show direction of currents.

By such an arrangement I believe a sufficient scour may be obtained so as to keep a deep channel along the inner surface of the outer breakwater and that

it would only deposit a comparatively small quantity within the present harbor, carrying most of it away eastward to be deposited either out at sea in deep water, or behind the eastern harbor breakwater, where it can do no harm ; another advantage is that this plan admits of two ways for a ship to enter and leave the harbor ; a very important point for ships with the wind blowing on to the coast.

Having, I hope with sufficient clearness, explained my views with respect to Port Said, before speaking of the canal itself I may make a few remarks about the Suez end of the canal. Here at spring tides there is a rise and fall of 5 ft., and 3 ft. at neap tides, while at Port Said the rise and fall is only 9 in., though during strong gales the Mediterranean rises 18 in. The level of the two seas may be taken as identical, for by the last series of levels the difference was found to be only 3 in., the Mediterranean sea being the higher of the two.

Up to the time of my leaving Suez, no observations had been taken to determine with any great accuracy the velocity of the tides in and out of the canal at Suez, but it had been observed that there is a slight flow of water through the canal northwards from the Red Sea to the Mediterranean; but that it is very slight I can testify, for on one of the occasions when we dropped anchor in the small steamer going up the canal (we never did so coming down), I dropped crumbs of bread into the water, to try and discover if there was any current, and though I could perceive the bread sinking 2 or 3 ft. below the surface, yet I could not perceive any current up or down the canal. That there is a slight current northward I believe, and the question is how to account for it. The tidal wave passes Suez at a considerable velocity, and reaches the Bitter Lake probably before high water at Suez, so there is a regular stream into this lake.

The momentum thus given to the water will keep a stream of water pouring into the lake long after high water at Suez; for the area of the lake being several square miles, the rise in it will be little, comparatively speaking. As soon, however as it does rise, there must be a similar flow northward through the canal into Lake Timsah, which will slightly raise its level; and, again, if this level be thus raised above the main level of the Mediterranean, a similar action will take place here also, and water will flow northward; very slight, indeed, but enough to prevent it being quite stagnant.

Again, with the ebb tide, the rise of the level water in the Bitter Lake being so little, and it being upwards of 15 miles from the Red Sea, connected by a narrow canal, the few inches rise can have but little effect in causing a flow out of the lake southwards between half ebb and half flood; so that the outflow southwards must be much less than the inflow northwards; for every one who has observed the time of high and low water, and the time of the turning of the tide, must know that owing to the momentum the current has attained, the water begins to rise or fall some time before the tide turns in mid-channel.

Now, as the rise and fall in the Red Sea is 5 ft., the rush of the tidal wave up the canal northwards must be much greater than can possibly be attained by a slight rise of probably a few inches, and the extra momentum thus attained by the flood must take a considerable time to be overcome by the outflow back from the Bitter Lake—consequently the direction of the ebb must be shorter and less rapid; so the conclusion I thus arrive at is, that the average level of the Bitter Lake now, will probably be found to be somewhat higher than that of the Red Sea, even though there is a loss by evaporation.

It is thus I would venture to explain why there should be a flow northward up the canal from the Red Sea into the Mediterranean, but I hope shortly to be able to forward a note on the experiments now being made, which the officer in charge at Suez kindly promised to furnish me with. However, it has been generally observed that the flood tide at Suez up the canal is considerable, in comparison with the ebb. Be it owing to causes now given, or evaporation, or probably both combined, the effect on the canal channel will be to widen or deepen it at the Suez end; and unless the sides be protected it may become, in time, funnel-shaped like the mouths of all tidal rivers; so I think this should be guarded against, and rather deepen than widen the channel, for the transporting power of water decreases as the depth increases, it is believed ; and, therefore,

if this be true, less silt will be brought up the canal into the Bitter Lake. This, however, appears to be more a question of interest rather than importance; but in the case of the tendency to silting up of the mouth of the harbor of Port Said, it is quite another matter, and should be most carefully considered. I believe, however, that it will not become a pressing question for these next ten years, so that there is plenty of time, and before it arrives there will be, I believe, plenty of funds to meet the difficulty.

Having thus fully gone into the questions connected with the two extremities of the canal, I fear it would occupy too much time to describe the manner in which the breakwater is made of blocks of Beton, though it was fully explained to me, but which has already been described in several works, so I content myself by sending a specimen of the Beton made for the Port Said breakwater.

Regarding the canal itself there is no necessity to say much, for in an engineering point of view, it is simply a great ditch, hardly exceeding the Ganges Canal in cross-sectional area at some parts, and much less than it as to length. Any one who has seen the deep digging at the Synabas ridge at the 12th mile of the Ganges Canal, and the Purean Kullea one 5 miles further down, before the slopes were dressed off, can form a pretty correct conception of what the appearance of the Suez Canal is in deep digging, with this difference only, that we had clay where in Egypt they had chiefly sand. In opening the Suez Canal for traffic before the slopes were dressed, I think the Canal authorities showed great sense, for such a work looks much more imposing before than after the slopes are dressed.

As an engineering work the difficulties to be overcome were little in comparison to those on the Ganges Canal, where so many mountain torrents had to be crossed, and a channel had to be dug, and regulated by falls for a running stream, not a still water one; while on the Suez Canal there are neither locks, bridges, nor falls, and all these difficulties may have been said to have been overcome when they got fresh water, and the dredges were set to work, for then it was only a question of time and money.

It is not necessary for me to say anything about the dredges, and how they worked, but I will pass them by as the French Engineer did, who had been describing to me the process of making Beton, when he said "that is the steam engine which drove the works, but there is no need wasting time looking at it."

The two difficulties, I may say the enormous difficulties, the Suez Canal authorities had to overcome, were the organization of labor and the want of fresh water. Any one who has had 5,000 or 6,000 workmen to keep in order out in India can but form a slight idea of the difficulties of collecting people of all nations, Europe, Asia, and Africa, and organizing them into efficient laborers; but this was effected by the same process which never fails in India, namely, paying one and all for the actual work done.

As to the want of fresh water I shall simply mention that at one time the chief engineer had, he told me, three thousand camels employed bringing to the works the necessaries of life; so I need say no more as to the difficulties at starting; any one who has ever been exposed to a burning sun, and short of water, can imagine the rest. So I shall pass on to the question of drift sand.

That this has and will cause trouble and inconvenience there can be no doubt, but I look on it more as a "bugbear" than anything else. That sand in large quantities is moved by the wind, and will be blown into the canal, no one will dispute; but when the remains of canals made thousands of years ago are to be found, surely the Suez Canal is not going to disappear all at once by a dust storm; but this also may be overcome, of which more hereafter.

The next difficulty raised is the silt deposit in the canal. It has been already shown that there is no current to speak of in the canal, except at the Suez end, so the mischief is confined to the last 15 miles of the canal, and till I get a report of the observations that are now being taken, I cannot speak with any certainty as to the velocity or scour along this portion, but from what I observed, I do not anticipate much difficulty even in this short distance.

A very important question, which, though it may not be seriously entertained now, will most probably be brought

forward ere long—namely, as the level of the sweet water canal at Ismailia is several feet above that of the Timsah Lake, could not more water be taken from the Nile to fill the lake and the canal to a higher level for 10 miles on the south side, and some 7 miles on the north, and have a set of locks at both ends to descend again to the levels of Lake Ballah and the Bitter Lakes?

Ship-masters may say there will be delay in passing through the locks, but this could hardly occupy half an hour, and it has been shown that there are from 2 to 4 hours at least to spare; so time can be of no moment, for under any circumstances it will take two days to pass from Suez to Port Said except in cases of emergency seldom likely to occur. There will practically therefore be no delay by having locks with the centre portion fresh water, but possibly a saving of time, for ships could while at anchor get a supply of fresh water of the Nile, and bringing the ships into a fresh water lake will most certainly kill the marine animals attached to the ships' bottoms; thus, instead of a loss of time, there probably will be a great gain by the ships leaving the canal with comparatively clean bottoms.

This, however, is not the advantage I look forward to, but to the reclamation of the desert by irrigation; which is not a matter of doubt but certainty, for there are proofs existing to show that canals were made near Ismailia by the ancient Egyptians; so we would only be carrying out what was formerly done several thousand years ago, and the gardens of Ismailia show that only water is required to make the soil most fertile. With Lake Timsah converted into a fresh water lake, which formerly it most probably was (as "Timsah" signifies crocodile, and these creatures live in fresh or brackish water), there could be no difficulty in running branch canals from above the locks, so that all the ground round the Bitter Lakes on both sides, as well as that of Lake Ballah, could be reclaimed, and not only would the Egyptians be enriched, but the Canal Company need no longer fear sand storms. This can no doubt be still carried out by siphons and pass the fresh water under the salt water canal, but the expense would be considerable.

To carry out all that appears necessary is to widen the present fresh water canal from Ismailia to the Nile, and probably a permanent weir or anicut with regulators would be required to be thrown across the Nile near Cairo, where stone is to be had in any quantity. Though this project may at first sight appear too great, yet when it is contemplated to construct similar works across such rivers as the Ganges and the Sutlej, where no stone exists, but all must be made of bricks, the proposal does not appear so problematical as some may at first sight think, and I believe it could be carried out at a comparatively little cost.

With a weir and regulators at Cairo, a complete command could be had over the supply, so that the whole irrigation system of Egypt could be vastly improved; for there would be no waiting till the Nile rose, as has been the case, but the water could be held up to the required level at all seasons. The work in fact would be similar to the Godavery anicut in Madras, only on a somewhat smaller scale as to length of work.

These permanent works would have to be constructed by Government, probably by contract, and would to all intents and purposes be a State work, chargeable to the whole community, for all would be benefited more or less; so unpaid labor had better not be employed on such an undertaking, for skilled labor would be required.

In widening the present fresh water canal, however, the ancient laws of Egypt could be put in force with advantage, as the laborers who perform this work would have the first claim on the land to be recovered from the desert, so they would be remunerated by receiving title-deeds to plots of land according to the work performed; thus all would be done without putting the Government or the Suez Canal Company to any extra outlay, while it would be quite in the spirit of the ancient Egyptian laws, to which I referred in my other report on Egyptian irrigation.

In 1865, before I knew anything about these ancient Egyptian laws, I suggested in my report on the irrigation of the Rechna Doab, that to induce people to come and work on the proposed canal at low rates, a promise of land should be given to the laborers according to the actual work done by them, and I stated my belief that such an inducement would

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draw crowds of laborers, who would gladly work at comparatively low rates under such a promise. What I have since learnt while passing through Egypt confirms me in this opinion, and I think it should be tried on all new canals where large tracts of waste land are to be reclaimed.

Viewing the matter in this light, it appears to me that making Lake Timsah fresh water would be adding wealth to the Egyptians, while probably also it would be a saving to the shareholders of the Suez Canal. Widening and deepening the canal, as some think is necessary, must be very expensive in deep cutting, if not a difficult and tedious process where the belt of rock crosses the line, while to build two locks at either end before entering the Ballah and Bitter Lakes is a simple affair; so both in an engineering and also in an economical point of view this suggestion appears worthy of consideration; but be it adopted or not, I for my part have little doubt that the Suez Canal will prove a blessing to the whole world, to India in particular, and will ere long enhance Indian revenues several millions yearly by the enlargement of commerce with the West.

We all know, by experience, that with canals in India there is a time of infancy as well as manhood, and that they take several years before they become remunerative. Possibly such may be the lot of the Suez Canal, and that for a few years to come the transit dues will hardly cover the working expenses, in which case there will be a great loss to the shareholders, and a greater outcry; but as the canal is now admitted, as far as it goes, to have been a success, and that it will ultimately prove to be a general benefit to the world, let it not be said that the nations of Europe and Asia allowed the loss to fall on the pioneers who constructed this great work.

That the work has been honestly executed and paid for, I have every reason to believe, for on examining the mode adopted of periodically making sections of the work done and measuring up the whole each time, deducting former progress, shows that it would be next to impossible to use fraudulent measurements; for not only the contractors, but the workmen were paid by these measurements, so that if, at any time, too great a progress was given and afterwards this excess was deducted, the workmen who were last employed would not be long in pointing out that they had been defrauded, and if this was customary and these complaints were not heeded, the work would have soon come to a close. The fact, therefore, that the workmen agreed to be paid by such a system, where the men employed could not probably be always the same, proves to me that the utmost care must have been taken to have correct measurements; in other words, quantities can without difficulty be submitted fraudulently; with measurements the fraud is most liable to detection.

Believing therefore that the expenditure has been honestly accounted for, and bearing in mind the enormous difficulties that have had to be overcome, and the benefits likely to accrue, I think that an international guarantee against loss to the shareholders should be given, India bearing its share of this responsibility; or if need be, that a sum of £25,000,000 should be subscribed, and that the £16,500,000 expended, plus the interest on capital from the day of official opening to the day of settlement, should be paid to the shareholders.

With the balance remaining over, the canal could be put in complete working order, and light-houses built in the Red Sea, while by such an arrangement the transit dues need only be nominal—only sufficient to cover working expenses—thus, the returns to each subscribing power would arise from individual sources rather than direct taxes on ships passing through the canal.

In advocating these views, I do so without having any personal interest in the matter, or knowing any one who has money invested, but simply from a feeling of justice and gratitude all must feel to those who have conferred such a great benefit on the civilized world.

It is intended to have 16,000 tons of iron for the Northern Pacific Railroad at Duluth, before navigation closes. From Erie, Ward's steamers will take 5,000 tons, and sailing vessels as much. Part of this has gone forward. The Winslow line is to bring 3,500 tons from Cleveland. This will be enough for about 200 miles of road.

METEOROLOGICAL TABLE OF TEMPERATURE, ETC., FOR TWENTY-FIVE YEARS.

By Prof ORAN W. MORRIS, New York City.

—	Mean Temperature for 25 Yrs.	Highest, and the Month.	Lowest, and the Month.	Warmest Day of the Year, and Sum.	Coldest Day, etc.	Average of the Seasons.				Quantity of Rain.	Average Rain.	Greatest Rain in One Month.	Least Rain in One Month.	Rainy and Snowy Days.
						Spring.	Summer.	Autumn.	Winter.					
	Deg.	Deg.	Deg.		Deg.	Deg.	Deg.	Deg.	Deg.	In.	In.	In.	In.	
1845....	51.450	90.0 July.....	6 Feb.....	June 9 78.50	Feb. 1 6.00	47.160	70.110	56.480	31.850	35 250	2.862	4.93	1.240	113
1846....	50.560	91 "	3 "	July 11 84.50	" 19 85.00	47.102	71.230	55.306	28.260	47.067	3.975	8.940 Feb...	0.870 Sept..	117
1847....	50 492	88 June & July	11 Jan.....	" 19 85.00	Jan. 28 10.25	45.885	70.231	53.194	30.960	42.44	3.858	7.51 Sept..	0.98 Apl...	135
1848....	51.092	89 June.....	3 "	June 17 81.50	" 22 15.00	48.899	70.768	50.848	37.026	41.741	3.794	7.16 June..	1.87 Feb...	114
1849....	49.582	92 July.....	− 4 "	July 13 87.50	" 10 10.25	46.116	70.064	54.491	29.536	35.546	2.966	5.98 Oct...	0.65 Jan...	130
1850....	51.765	90 "	11 Feb.....	" 30 83.875	" 11 3.75	45.792	72.607	54.727	44.840	50.329	4.194	6 659 May..	1.965 Nov..	149
1851....	51.974	92.3 June.....	7.8 Jan.....	June 30 82.700	Feb. 5 14.625	46.920	73.190	53.670	31.840	45.844	3.820	6.442 Apl...	1.282 Sept..	139
1852....	51.400	93 July.....	− 2 "	.....	Jan. 30 10.36	49.020	72.690	55 800	31.070	43.840	3.653	6.200 Aug..	2.06 Oct...	126
1853....	52.240	98.2 June.....	9 "	July 20 86.66	Dec. 20 10.00	49.320	72.500	54.240	32.900	42.435	3.536	10.11 Apl...	1.06 Aug..	99
1854....	51.682	95 July	3 Dec.....	" 18 87.40	Feb. 6 0.50	48.220	73.867	55.320	30.174	42.435	3.536	10.11 Apl...	1.06 Aug..	126
1855....	51.066	93.5 "	− 8 Feb...	" 19 88.43	Jan. 9 0.73	47.357	70.912	55.305	27.831	52.910	4.419	7.37 Oct...	1.51 Sept..	151
1856....	50.536	95 "	− 5 Jan.....	Aug. 14 85.20	" 18 2.53	45.633	73.648	55 563	28.073	40.502	3.375	6.73 Aug..	0.66 Feb...	105
1857....	52.199	90 Aug.....	0 "	June 26 87.80	Mar. 5 11.16	47.570	71.880	55.852	31.320	53.880	4.490	9.05 Apl...	1.30 Nov..	135
1858....	53.161	93.5 June.....	− 3 Feb...	July 11 85.16	Jan. 10 2.90	48.293	74.647	55.305	32.571	51.070	4.256	6.42 June..	1.47 Mar..	123
1859....	53 120	96.5 July.....	− 8 Jan.....	June 30 83.26	Feb. 2 7.43	52.235	72.673	54.411	34.382	55.66	4.640	8.21 Mar..	1.57 May..	163
1860....	52.884	89 "	− 7.7 Feb...	July 9 84.90	" 8 3.06	50.251	73.170	55.919	32.046	45.17	3.760	7.57 Nov..	1.43 June..	167
1861....	53.870	92 Aug.....	− 3.1 " ...	Aug. 9 88.63	Dec. 20 13.10	49.456	73.063	57.500	33.783	54.65	4.554	8.09 " ..	1.73 Dec...	144
1862....	53.255	95.4 "	8 Dec.....	" 3 89.40	Feb. 4 8.33	50.750	72.425	57.883	33.706	53.97	4.497	9.03 June..	1.91 " ..	169
1863....	54.239	95 "	6 Feb.....	June 26 91.26	" 10 10.00	49.130	75.454	56.630	36.082	57.03	4.752	8.60 July..	1.05 Sept..	157
1864....	55.410	97 June.....	8 "	July 28 86.56	Jan. 27 13.43	51.960	76.936	55.716	36.010	47.61	3.969	5.90 Dec...	2.04 Feb ..	157
1865....	55.508	95 July.....	−13 Dec.....	" 17 90.93	" 8 2.33	54.389	77.396	57.469	32.139	62.98	5.248	10.42 June..	2.23 Aug ..	144
1866....	52.125	98.8 "	−13 Jan.....	June 30 87.86	Dec. 13 8.23	49.613	72.166	54.856	34.280	52.23	4.350	10.09 Feb...	1.67 July..	150
1867....	49.887	91 June.....	4 "	July 16 84.83	Feb. 3 6.30	45.290	70.926	54.186	30.360	54.655	4.554	10.18 June..	0.78 Sept.	108
1868....	48.669	92 July.....	− 0.5 Feb...	Aug. 20 84.66	Jan. 22 16.83	44.908	71.909	52.156	25.603	64.03	5 336	9.60 Sept..	2.01 Oct...	165
1869....	51.503	93 Aug.....	8.5 March..			47.229	71.844	53.441	31.257	55.535	4.628	7.29 Feb...	1.57 Apl..	171
Mean...	51.987	.....	.....	.....	.....	48 341	72.652	54.811	32.314	49.563	4.188	.....	.....	139.5

The Table of temperature presented above, embraces a statement of the observations made during a series of 25 years, in the city of New York; and comprises the annual means; the maximum and minimum; the warmest and coldest days; the means of the seasons; the quantity of water from rain and melted snow; the number of days on which rain or snow fell; and some other phenomena.

The average temperature for the 25 years is 51.987 deg.; the series shows but little variation from the average. The first 12 years, with the single exception of 1853, are all below the average; the next 10 years are above, and the 3 last below—1868 being the lowest of the series, 48.669 deg., or 3.318 deg. below the normal; 1865 is the highest, 55.508 deg., or 3.521 deg. above the normal, and 6.839 deg. higher than 1868.

The maximum, at 2 P. M. was 98.8 deg., July 17th, 1866; this was 49.033 deg. above the normal (at 3 P. M. of this day it was 101.02 deg. for a very short time). The minimum was 13 deg. below zero, twice—once Dec. 8th, 1865, the other, Jan. 8th, 1866. It was above zero, in 14 years; at, or below, in 11 years—5 times in Jan. 5 times in Feb. and once, in Dec.

The maxima of the series are quite as uniform as the means, varying only about 11 deg., *i. e.* from 88 deg. to 98.8 deg.; the minima varied from 11 deg. above to 13 deg. below, a range of 24 deg. In 1866, the maximum and minimum both occur, showing a range of 111.8 deg.; besides being the warmest year of the series.

The warmest day, June 26th, 1864, was 91.26 deg. above zero; the coldest day, Jan. 8th, 1866, was 2.33 deg. below—a range of 93.59 deg., with an interval of $1\frac{1}{2}$ years. The warmest days in each year were very uniform, only 1 being below 80 deg.; the coldest days ranged from 2.33 deg. below zero, to 16.83 deg. above, having an interval of nearly 3 years between.

The different seasons are each quite uniform also. The means for the spring was 48.341. Of these, 13 are below the mean, and 12 above it. The warmest spring was in 1865, 54.389 deg.—6.048 deg. above the mean; the coldest, was in 1868, 44.908 deg.—3.633 deg. below it, a range of 9.481 deg. The mean for the summer was 72.652 deg.; of these, 13 years were below, and 12 above, the mean. The warmest was in 1865, 77.396 deg.—4.744 deg. above the mean; the coldest in 1845, 70.11 deg., 2.542 deg. below—a range of 7.268 deg. The mean for autumn, 54.811 deg., gives 8 years below the mean and 17 above; the warmest was in 1862, 57.883 deg.—3.072 deg. above the mean; the coldest in 1848, 50.848 deg.—3.963 deg. below a range of 7.035 deg. The mean for winter was 32.314 deg., with 13 years below it, and 12 above; the warmest was in 1848, 37.026 deg.—4.712 deg. above the mean; the coldest in 1868, 25.603 deg., 6.711 deg. below it, a range of 11.423 deg. In the series for spring there were only 5 years above 50 deg. In the series for summer, all were above 70 deg. In the autumnal series, they were all above 50 deg., and in that of winter there were 5 below 30 deg. Some months, in each season, were much warmer, and others much colder than the corresponding months in other years.

The average quantity of water from rain and melted snow was 49.563 in.; 15 of the years were above the mean, and 10 below. The greatest quantity in any one year, was in 1868, 64,030 in., 14,467 in. above the mean; the least was in 1845, 35,370 in., 14,213 in. below a range, in quantity, of 26,68 in. The average quantity per month was 4,188 in.

The difference not only in quantity in different years and months, but also in the number of days on which rain or snow fell, is suggestive, as indicating the necessity for a careful and scientific system of sewerage to preserve the health of cities and towns.

The average number of days on which rain or snow fell was 139.5 days. Of these, 13 years were below the mean, and 12 years above. The largest number of days in any one year was 171, in 1869, and the smallest was 99, in 1853.

In this series for New York city, the coldest weather occurred 4 times in January, 10 times in February, 3 times in December, and once in March. The warmest weather occurred 13 times in July, 7 times in June, 4 times in August, and once in both June and July.

The Spanish foot is equivalent to 11.03 English in.; the Prussian, 12.36; Austrian, 12.45. Russian, 13.75; Portuguese, 12.96.

IRON AND STEEL NOTES.

STATEMENT of the export of rails from Great Britain, compiled from official returns published by authority of the House of Commons:

COUNTRIES.	Month ending Oct. 31.		
	1868. Tons.*	1869. Tons.	1870. Tons.
AMERICA.			
United States	18,723	18,743	28,219
British	302	260	4,793
Cuba	644	....	10
Brazil	195	1,091	281
Chili	10	115	869
Peru	1,087	....	349
EUROPE.			
Russia	30,627	50,607	10,196
Sweden	14	505	474
Prussia	466	3,508	2,603
Illyria, Croatia, and Dalmatia	2,362	553	2,578
France	41	315	20
Holland	547	203	252
Spain and Canaries	1,848	613	936
ASIA.			
British India	2,742	10,320	8,658
Australia	422	2,004	417
AFRICA.			
Egypt	....	26	102
OTHER COUNTRIES.	3,665	7,581	9,016
Total	63,605	96,444	69,773
Pig Iron to U. S.	7,435	13,668	12,875

COUNTRIES.	Ten Months ending Oct. 31.		
	1868. Tons.	1869. Tons.	1870. Tons.
AMERICA.			
United States	228,091	262,829	341,629
British	15,535	23,929	34,705
Cuba	2,662	885	3,199
Brazil	2,171	2,913	3,232
Chili	1,450	2,762	13,849
Peru	3,159	18,720	13,680
EUROPE.			
Russia	100,554	247,278	204,005
Sweden	1,596	3,938	2,595
Prussia	5,721	14,910	41,912
Illyria, Croatia, and Dalmatia	10,498	22,317	35,495
France	161	4,235	362
Holland	21,113	10,078	15,212
Spain and Canaries	7,392	11,609	10,880
ASIA.			
British India	61,333	76,200	140,845
Australia	8,131	19,842	7,798
AFRICA			
Egypt	10,512	6,051	2,116
OTHER COUNTRIES.	29,889	65,123	60,477
Total	509,968	793,619	931,991
Pig Iron to U. S.	75,504	118,297	97,586

* Tons in a l casgs 2,000 lbs.

—*Bulletin of American Iron and Steel Association.*

IRON TRADE ON THE CONTINENT.—The Anglo-Russian difficulty not having become more threatening up to this present writing—although it is impossible to say what a few hours may involve one way or the other—Belgian industrials have somewhat regained confidence, and have begun to hope for a peaceful solution. At any rate, they greatly desire it, as a war between England and Russia would be a rude shock to Belgian metallurgical industry. The Belgian blast furnaces are still disposing of their production tolerably well. The imports of iron minerals into Belgium, in August, amounted to 38,357 tons, against 57,461 tons in August, 1869; in the first eight months of this year they footed up to 424,130 tons, against 376,924 tons in August, 1869. The total imports of iron of all kinds into Belgium in August, 1870, amounted to 3.517 tons against 4.059 tons in August, 1869; and in the first eight months of this year to 65,543 tons, against 37.235 tons in the corresponding period of 1869. The exports of minerals from Belgium amounted in August to 13,242 tons, against 10,294 tons in August, 1869; and in the first eight months of this year to 127,396 tons, against 108,525 tons in the corresponding period of 1869. The exports of rails from Belgium declined in August to 7,132 tons, against 19,486 tons in August, 1869. The rail exports of the first eight months of this year were 93,889 tons, against 103,746 tons in the corresponding period of 1869. The exports of rails to the Zollverein, France, and Spain, show a marked increase; those to Russia, the Low Countries, Turkey, Italy and the United States exhibit a sensible decrease. The annexed table shows the exports of iron of all descriptions from Belgium during the first eight months of 1870 and 1869:—

Destination.	1870.	1869.
Russia	Tons 45,611	55,097
Sweden and Norway	1,850	732
Denmark	75	598
Zollverein	34,901	22,507
Hanse Towns	2,609	3,162
Low Countries	16,198	18,665
England	8,481	8.347
France	28,067	27,295
Spain	2,917	353
Italy	6,670	13,493
Switzerland	2,809	2.286
Austria	1,197	1,320
Roman States	35	28
Turkey	16,738	27,429
Egypt	1,493	30
United States	6,954	10,313
Cuba and Porto Rico	1,337	691
Brazil	362	663
Rio de la Plata	111	440
Chili and Peru	273	361
Other destinations	130	364
Total	177,818	197,114

In these totals August in each year figured for 15,447 and 31,605 tons respectively. Makers of railway plant in Belgium were recently promised by the Belgian Minister of Public Works an order for 520 trucks and 30 locomotives, but they have not yet actually received this commission.

PRICES OF STEEL RAILS.—The correspondent of a leading English journal, writing from Birmingham, says that in that city conspicuous men-

tion is being made of the rapid advance in the price of steel rails. "I have,' says he, "often spoken of the scarcity of ore that, as far as is yet known, can alone be utilized to make Bessemer iron. That scarcity is being increasingly felt; and as the manufacture of steel by the Bessemer process is concentrated in few and powerful hands, the natural tendency is towards higher prices. Steel rails are now quoted at £11 5s. a ton—a price considerably higher than that at which they stood when a high royalty had to be paid to the patentee. These facts are giving rise to much investigation by geologists of localities anywhere supposed to possess the much-coveted mineral; and speculators here are looking for such property as a desirable means of investment."—*American Artisan.*

VARNISH FOR IRON.—The following is a method given by M. Weisskopf, of producing upon iron a durable black shining varnish:

"Take oil of turpentine, add to it, drop by drop, and while stirring, strong sulphuric acid, until a syrupy precipitate is quite formed, and no more of it is produced on further addition of a drop of acid. The liquid is now repeatedly washed with water, every time refreshed after a good stirring, until the water does not exhibit any more acid reaction on being tested with the blue litmus paper. The precipitate is next brought upon a cloth filter, and after all the water has run off, the syrupy mass is fit for use. This thickish magma is painted over the iron with a brush; if it happens to be too stiff, it is previously diluted with some oil of turpentine. Immediately after the iron has been so painted, the paint is burnt in by a gentle heat; after cooling, the black surface is rubbed over with a piece of woolen stuff dipped in and moistened with linseed oil. According to the author, this varnish is not a simple covering of the surface, but it is chemically combined with the metal, and does not, therefore, wear or peel off, as other paints or varnishes do from iron."—*Journal of Applied Chemistry.*

ELECTRO DEPOSITS OF IRON.—Printers have for a long time complained of the fragile nature of the copper stereotypes, so easily damaged by a few irregularities in the paper, or through dust coming in contact with them while printing.

E. Klein, a Russian mining engineer, has succeeded in obtaining iron electro deposits suitable for printers, offering the great advantages of cheapness and durability. The samples produced by Mr. Klein give us assurance that this discovery will find its application in different manufacturing processes where the copper electro deposits now have such importance.

In 1867, M. Feuquieres exhibited at the "Exposition Universelle," samples of iron electro deposits, but the process of Mr. Klein differs entirely from the one used by Feuquieres.

Klein, in order to increase the solubility of the iron anode, used a similar composition to the one employed by Jacobi, in 1856, for the electro-chemical decomposition of the silver baths. As a proved fact, the quality of the iron electro deposits depends entirely on the more or less solubility of the anode, the most soluble yielding the best results. It was at first thought that in increasing the surface of this anode it would bring a better result, but the result of the experiment was not successful. Mr. Klein then combined copper anode with an iron, or, according to Jacobi's experiments, replaced the copper by graphite or retort coke. The effects of such a combination can be explained as follows:

The negative metal combined with the iron in the bath has a double action; it acts as catode against the iron, and as anode by its combination with the positive pole of the battery yielding the principal electrical current. Then, at the surface of this electrode, hydrogen and oxygen are evolved simultaneously; these, in a nascent state, combine in proportions to form water. The excess of hydrogen is set free or produces a polarization of the electrode; if the oxygen is more abundant and if the electrode is made from an inoxidable body, as the retort coke (graphite), there will also be gas evolved and a small polarization, but if the electrode is oxidable, as for example the copper, it will then be oxidized and dissolved.—*Journal of Applied Chemistry.*

RAILWAY NOTES.

IMPORTANT RAILROAD CASE.—In the suit in the Supreme Court brought by Frederica Klumbach against the New York Central Railroad Company, relating to the buffer irons and cheek blocks between freight cars, whereby her son, a brakesman, was killed, a verdict has been given against the Company for $3,500.

Without reference to the merits or the important legal questions involved in this particular case, it is to be hoped that it will be the means of leading the directors of railroad companies to look for themselves whether their arrangements for the coupling of freight cars are such as ordinary humanity requires, and whether the cheek blocks on the end of freight cars project far enough to preserve the lives of brakesmen whenever the buffer irons give way or prove defective.

Many human beings have been crushed to death between freight cars. A measurement of cheek blocks on the New York Central freight cars shows that in some instances these cheek blocks project only 3½ in., sometimes only 4½ in., and sometimes only 6 in. Thus, if the buffer irons of opposite cars should be broken and the cheek blocks come together, there would in some instances be for the brakesman a space of only 7 in., sometimes 9 in., and sometimes only 12 in. Now, according to the testimony of experienced brakesmen, as well as medical testimony, 16 in. is the very least space into which a brakesman should be asked to stand, especially as the freight cars frequently come together with great force.

At the trifling expense of one or two dollars on each car, each cheek block could be made to project 8 in., and thus secure for the brakesman a clear space of 16 in., even if both buffer irons were broken off or driven back under the cheek blocks. This ought to be done with each new freight car, and with the old ones whenever brought into the shop for repairs; and thus in one or two years every freight car on the road would be so constructed as to save the lives of brakesmen, and save the Company from the appearance of needless cruelty and from expensive lawsuits.

Experienced brakesmen think the danger attending the coupling of freight cars is unnecessarily increased by allowing the ends of the side sills to project beyond the cross sills into the space through which brakesmen must pass when going in between

cars to couple them, or when attempting to come out.

From October 1, 1868, to October 1, 1869, 41 employees on the railroads in this State are reported as injured or killed while coupling cars. Of this number, 27 are reported on the Erie Railroad, 4 on the Buffalo & Erie, 3 on the New York Central, and 3 on the Hudson River Railroad.—*Exchange.*

A Thirty-inch Gauge Railway in Ohio.—The Toledo "Commercial" having stated that the Piqua, St. Mary's & Celina R. Co. had been incorporated on a capital basis of $400,000, to build between Piqua and Celina, through Miami, Shelby, Auglaize and Mercer counties, Ohio, about 44 miles, a Piqua correspondent gives us the details of the scheme.

The country along the line is very populous and productive, and the question of an outlet by railway has long been agitated. But the Miami & Erie canal passes through it already; and while inadequate to the wants of the country, there is scarcely warrant for the construction of an expensive road. Last winter, the plan of a narrow-gauge road was proposed and discussed,—costing, fully equipped, less than half a million of dollars, in place of one of the ordinary gauge costing a million and a half. The design is identical with that of the Welsh railways, which have been so often described in engineering journals of late. A road of this kind for transporting coal is already in operation (the only one in this country as yet,) between Akron and Massillon, Ohio. A system of narrow-gauge railways is also projected from Toronto, Canada, as feeders to the wide-gauge roads now centring there. We learn that parties interested in the proposed Buffalo & Springville Road are now examining the Canada system, with a view to the adoption of the narrow gauge. The Kansas & Denver Pacific Companies also contemplate reaching the mining regions near Denver, and probably at no distant day penetrating the Great Mountain Parks, and perhaps passing over the entire range, by narrow-gauge roads costing only one-seventh as much as the present gauge, where the latter is practicable. In all these cases the data showing the entire practicability of these roads, and giving the cost of construction and operation are such as to reduce the prospects of any such enterprise to a certainty.

To return to the Ohio Road. The right of way is to be 15 ft. in place of 40 ft.; 20 lbs. instead of 56 lbs. iron will be required; the locomotives, weighing 6 tons instead of 30, will draw from 10 to 20 loaded freight cars, each having a capacity of 2½ tons; under freight and passenger cars alike (the latter seating 20 persons), four-wheel trucks will be placed; the ties will, of course, be nearer than on the wide gauge; while finally, on account of the lightness of car equipment, in comparison with capacity, and of the central position of the trucks, both higher gradients and sharper curves are practicable, greatly reducing cost of excavation and other important items of construction.

In the present instance, the route presents no engineering difficulties—Piqua, thence following the canal to Berlin; thence to Minster, Bremen, and St. Mary's, where it will leave the canal, and make Celina its Northern terminus.

The enterprise, which is to be begun in January, is in the hands of able and energetic citizens—among the corporators being Hon. J. F. McKinney, member of Congress elect; William Scott, one of the oldest citizens, and President of the Piqua National Bank; J. G. Young, Cashier of the same; Henry Flesh, a wealthy merchant of the city; Chas. C. Clute, an experienced railroad builder, of New York city.—*Chicago Railway Review.*

The Railway System of Europe.—The railways of Europe and America form systems by means of which the business circulation of nations is kept up. But the two systems differ very materially. The European system was devised with a full recognition of the public necessities and ultimate interests involved, while our own has, until quite recently, been a natural growth, controlled by no particular policy, and restrained by no governmental authority. Many of the European roads were either constructed by the Government, or under grants which allowed the authorities to retain control of them—Great Britain, we believe, being the only exception.

In France there were, according to the latest reports, over 9,000 miles of railroads in operation, all constructed since 1836, at an average cost of $125,000 a mile. They were built under the supervision of the Government, and were largely aided by Government loans. They are now leased to six great companies, for a term of ninety-nine years, and pay the Government ten per cent. of the gross receipts. At the end of the lease the roads revert absolutely to the Government, but meanwhile the mails are transported free, and troops and Government property at reduced rates. The rates to be charged the public by the roads for freight and passage are fixed in the leases, and are so profitable that the stock of the companies steadily commands a premium. From their yearly profits the companies are also obliged to put by a certain sum, which, at the end of the lease, is to be used to reimburse the shareholders for their original investment. This tends still further to give stability and public favor to the stocks.

Belgium has but 1,250 miles of railroad, constructed at an average cost of $91,500 a mile. These roads, like those of France, were constructed partly by the Government, and partly by companies which received their franchises on condition that their capital should be gradually refunded, with a liberal interest, and that thereupon the roads should revert to the State. At first the Belgian roads returned no profit, but of late years, by reason of increased business, they are paying the shareholders seven per cent. per annum. Prussia has 3,800 miles of railroad, costing $33,700 per mile. Of these lines about one-half are worked entirely by the Government, and the rest by companies under concessions very similar to those made in France. One feature of the Prussian system is peculiar. The Government will not permit the construction of competing lines, nor allow combinations between any two or more lines.

Austria has 3,700 miles of railroad, costing an average of $108,500 per mile, and constructed by companies under concessions by which the roads become the absolute property of the State at the end of ninety years; meanwhile the rate of fare and freight charges being regulated by the Government. The roads have proved profitable, and have paid dividends of seven per cent., which seems to satisfy the Austrian capitalists, even with the prospect of obliterating the principal at the end of ninety years.

The railway system of England has been built upon an entirely different plan from that of any of the continental powers, and with the exception of the stricter governmental control which has been exercised, it is not very different from our American system. The roads have been built by private companies, and without restriction as to competition. There are 14,247 miles of railway in Great Britain, representing an aggregate capital of $2.511,314.435. The peculiar feature of the system is, that although the roads were built by private enterprise and capital, and do an enormous and increasing business, they do not, in the majority of cases, pay anything like remunerative dividends to the shareholders. Many of the principal lines have made no dividends for several years, and others make from 1 to 3 per cent. The London, Chatham and Dover, which cost $50,000,000, has never paid a dividend, nor even the interest on its first issue of bonds, and is now in the hands of a receiver. It seems strange to read, in the London "Railway News," that some of the roads are really in a flourishing condition, as compared with past years, and that they have declared dividends ranging from 4½ per cent. to 2 and 3 per cent.

The result in Great Britain is, that railroad investments have been almost total losses, and that the system has become so involved, and the stocks so depressed, that it has been seriously proposed that the Government should purchase all the lines at their actual market values, and run them in the public interest. The most sagacious railroad men in England express the opinion that ultimately this policy will be adopted, and that rates will then be put at a figure barely sufficient to defray the cost of maintaining and operating the roads. It will be seen that in all the Continental States such a policy is already provided for, and it seems probable that it will eventually become a general feature of the railway system in Europe.—*N. Y. Times.*

THE PANAMA RAILROAD.—The statement of the directors of the Panama Railroad for the period down to the end of September shows the sound condition of the Company, though the line has suffered from a considerable decrease in traffic since the opening of the Transcontinental route through the United States. The gross earnings of the road for the 9 months ending September 30, were $955,218 collected, to which should be added 150,000, the estimated receipts of parts of August and September, the returns for which had not come to hand, making a total of $1,105,218. The working expenses amounted to $388,870, as against $784,071 in the corresponding period of 1869, leaving the net earnings $716,348. From this has to be deducted the subsidy to the Columbian Government, and the interest on the bonded debt, leaving net for the 9 months $340,860. The condition of the Company at the present time is as follows:—The total cost of the railway, including payment for extended contract, was $9,500,000, of which $7,000,000 is represented by share capital. There is no floating debt, and to meet the bonded debt, of which the greater part matures in 1867, a sinking fund has been provided, on account of which a sum of $1,189,404 has been up to the present invested—sufficient, with accumulations, to retire all the bonds at maturity. The assets of the Company consist of cash and realizable securities, $747,468, the fleet of steamers and sailing vessels valued at $800,000, and real estate in and around Panama, worth, at cost, $73,140. There are besides vacant lands on the Isthmus in its possession amounting to about 300,000 acres, the value of which it is difficult to estimate. At the usual meeting of the directors of this road, held on the 24th September last, the present condition of the Company in its altered state, consequent on the opening of the Pacific Railroads, was taken into consideration, and it was resolved to return to the system of semi-annual dividends instead of quarterly payments, which have been made since 1862. The alteration is rendered necessary by diminished revenue of the Company, which the directors ascribe to several obvious causes. 1. The diversion of the traffic to the Pacific lines. 2. Establishment of competing line of steamers to West Coast of South America. 3. The reduction in rates for passengers and freights. 4. The increase of percentage of working expenses, owing to the impossibility of curtailing them as rapidly as the traffic fell off; and lastly, the decline in premium on gold. The directors look forward to a more satisfactory result for the ensuing year, by working the line with the most rigid economy, from gradually increasing business to be anticipated from reduction of freights, which will enable them to compete with the Pacific roads, and from business which will probably accrue from the anticipated establishment of new steam communication between Germany and the Isthmus.—*The Railway News.*

THE HONDURAS RAILWAY.—We have from time to time announced in these pages the shipment of cargoes of materials to be used in the construction of the Honduras Interoceanic Railway, and the arrival of consignments of mahogany despatched by the Honduras Government for realization here in fulfilment of its obligations with regard to this undertaking. It is only by such notices that the public is as yet informed of the continued progress of this vast and important undertaking. The line has hitherto, from its competition with interests vested in the Panama route, been the subject of continual misrepresentation, and the Transatlantic journals particularly indulge continually in depreciatory remarks as to the progress already made and the prospects of the line when completed. Its keenest opponents, however, cannot consistently deny the many advantages which the Honduras Railway, when completed, will have. As a means of communication between the Atlantic and Pacific oceans, the route by it is considerably shorter both as regards Europe and the United States, than that by the Panama line, while it will open up large and valuable tracts of country. There can be no doubt whatever that the line, when opened, will show as good or better results than the Panama Railway, as there is sufficient business for both routes, and the Honduras Railway will possess the advantages of easily accessible ports, with deep water at both its termini. The difficulty that has hitherto existed in the prosecution of the line is the want of labor, which, it will be remembered, was encountered also in the construction of the Panama route; but great exertions are now being made to obtain the necessary supply. The work is divided into three sections. The first section runs from Puerto Caballos, on the Atlantic side, to a point in the interior, close to the seat of Government. A great portion of this is already completed, and a locomotive is running on it, and native labor is now being

procured to press forward its completion. All the rails, the engines, and a portion of the rolling stock necessary for the section have been shipped, and the remainder of the rolling stock is now ready for shipment. With regard to the second section, a very large staff has been sent out from this country to make the surveys, and this staff has been engaged upon the works for the last four months; while all the rails and materials for the line have been purchased, and a portion of them shipped. A staff of engineers has also been employed during the same time on the third section, and workmen were sent to the Bay of Fonseca in the beginning of last month, to commence operations at that point. More recently the contractors' agent and manager has sailed with a further staff, and the supplies of plant for this portion of the work are being sent rapidly forward. There is now little doubt that the whole of the work will be completed by the end of next year—the time specified, and in the meantime public confidence in the success of the undertaking must increase. At the present time the stock is one of the cheapest in the market. At present price it pays 12½ per cent. interest. It bears 10 per cent. interest and has a drawing of £3, due on the 1st of January, and the present price includes £2 10s. of accrued interest. To investors seeking large returns, this stock should be in high favor.—*Railway News.*

AN ANDES RAILROAD.—Interesting information reaches us from South America, to the effect that a scheme is on foot for the construction of a railroad across the South American continent which bids fair to rival in extent, as well as in utility, the great transcontinental routes of the United States. A prominent engineer, Mr. Rossetti, was lately appointed by the Government of the Argentine Republic to make a thorough survey of the passes of the Andes, and his report seems to bring the undertaking within practicable compass. By the pass of the Planchon, or Teno, communication may be established between existing lines on either side of the Andes by a connecting line of about 1,000 miles in length. The highest elevation reached is about 10,827 ft., and apparently there will be but one very difficult section, in the Vargara Ravine, where there is a difference of level of 1,279½ ft. in a distance of 33,800 ft., which is a grade of 70 to 1,000. Thus, the undertaking will not be on the scale of our Pacific Railroad, either for length or the number of engineering difficulties to be overcome. The entire cost is calculated at about $3,000,000 or $30,000 per mile, of which the greater portion will be in the territory of the Argentine Republic, which has prosecuted the survey—only about one-fifth of the entire expense of the work, or about $6,000 falling upon the Government of Chili. It is quite possible that this undertaking may be considered too costly to be immediately undertaken, considering the traffic which it would command; but there are many important objects of public utility that would be served. The Argentine Republic has, we believe, great expectations, both from the immigration which is likely to flow into it, and the richness of the mining districts which will be opened. Beside these, there is a considerable trade between the eastern and western coasts, and the route would almost certainly command the mail and passenger traffic of Peru and Chili with Europe and the United States. Possibly it would form another practicable route between Great Britain and her Australian colonies. The original projectors of a railway over the Andes had at least the latter among the objects to be served by the road when completed. The line, it is said, might be built in four years, but the Argentine Republic will be surer of success in the undertaking if they take plenty of time to the work and gradually extend the line westward. The projection of such a scheme at the present time indicates a growing prosperity in the South American republics interested in the undertaking. We have been accustomed to look upon them as unprogressive nations, content to submit to the worst forms of anarchy that could exist under the name of organized governments, and probably this very general impression is not wholly without foundation in fact; but if a material enterprise as vast as the construction of a trans-continental railroad is seriously contemplated, it is evident that the two Governments interested in the proposed road are not wholly without resources, and have not lost entirely the confidence of capitalists and of the public at large. Thirty million dollars is rather more money than a disorganized anarchy, subject to periodical revolutions, could raise for internal improvements.

ORDNANCE AND NAVAL NOTES

THE PRUSSIAN PERCUSSION FUZE.—The percussion fuze used by the Prussian artillery consists of a small metal socket into which fits a metal striker, which is a nearly cylindrical piece of brass, having at one end a needle point. The socket with the striker in it is carried in the shell, being fixed in its place by means of a screw plug which screws into the nose of the shell. The screw plug is tapped for the reception of a small detonator, which, however, is not screwed in until the shell is required to be used. The striker, being free to move forward by its own weight, would, of course, be liable directly the detonating plug is screwed in, to cause an explosion by falling forward upon it, either by the accidental tilting forward of the head of the shell, or from the jar given in loading, or by the sudden movement of the parts at the moment of firing. To prevent this, a stout iron pin is passed through the head of the shell and through the fuze between the striker and the detonator, preventing any contact between the two. The centrifugal force generated by the rotation of the shell throws out the pin immediately the shell has left the bore, and there is now nothing to prevent the striker from coming into contact with the detonator. But this it cannot do until something occurs to suddenly check the flight of the shell—in other words, until the projectile impacts upon the ground or against some other obstacle, such as a man's body, which will momentarily reduce its velocity. At that moment the striker falls forward on the same principle and from the same cause as a bad rider is thrown over his horse's head when the beast stops suddenly in its gallop. These fuzes have been much extolled, and some writers have not hesitated to ascribe to them a great part of the successes of the Prussian artillery. To our minds the fuze is open to many serious objections. That it is very far from uniform or satisfactory in its action, even in peace time, is sufficiently proved by some figures which are given by Capt. Nicaise, in his pamphlet on "L'Artillerie de Campagne Belge." The Belgians, who copy the Prussians

very closely in their artillery *materiel*, use the Prussian percussion fuze, and Capt. Nicaise says that out of 8,245 shells and shrapnel fired with this fuze between 1863 and 1869, there were 128 premature bursts=1.5 per cent.; 433 fuzes slow in action=5.25 per cent.; 131 blind fuzes=1.59 per cent.; being a total of 692 failures=8.39 per cent. Exception may also be taken, we think, to the employment of a fuze which necessitates the operation of fixing a detonator and pin at the moment of firing—an operation which has to be very carefully performed for fear of accidents. If in the hurry of action the pin should be omitted, or if it should fall out of the shell, or if the man holding the shell and charged with the duty of keeping the pin in its place should happen to be shot, an accidental explosion, likely to be attended with fatal consequences to the gun detachment, must also certainly result. Other reasons might be given for not accepting the high estimate of this fuze, which, on insufficient grounds, seems to have been hastily formed. That the fuzes have done better than the exceedingly defective French time fuze does not prove much. At all events, the fuze is one which we should regret to see introduced into our service. Nevertheless, it may be fully admitted that the percussion fuze problem is very far from having yet been satisfactorily solved by our artillerists. It is one of exceeding difficulty; and it is quite certain that if we have not solved it in England, they are just as far or farther from having satisfactorily solved it in Prussia. In France it seems to have been abandoned in despair, and Belgium can think of nothing better than following the Prussians.—*Pall Mall Gazette*.

Breech-Loaders vs. Muzzle-Loaders.—The lesson afforded by recent great battles is thus set forth by a correspondent of the "London Times."

"As the question of the merits of breech and muzzle-loading field artillery, although settled very satisfactorily to its own mind at Woolwich by the great majority of English artillerists, is still open, and is warmly debated in beleaguered Paris, it is worth while to call attention to an unfinished article by an able writer, signing himself 'Littenant,' in the 'Debats' of the 4th of October. Relying on the details given in the work of Capt. Nicaise on the Belgian field artillery, which is almost identical with that of Prussia, the writer states—1st. As to rapidity of fire. To aim well it needs 11 min. to fire 35 rounds with a breech-loader, and 12 min. with a muzzle-loader. That is not much. 2d. As to precision, breech-loaders are incomparably superior. Here is the point on which in my small way I have insisted, and in spite of Woolwich do still insist, and will do so 'till better informed.' The table of averages for both systems, as given by M. Littenant, is as yet my full justification, if the battle of Sedan did not furnish one. The results of the experiments recited are as follows:—To touch infantry, the chances are for the Prussian gun of 4.90 per cent. at 500 metres, 70 per cent. at 1,000 metres, 50 at 1,500, 40 per cent. at 2,000. For the French muzzle-loader (to which we are assimilating) of 4, they are 80 per cent. at 500 metres, 40 at 1,000 meters, 23 per cent. at 1,500, 12 per cent. at 2,000! The French writer adds what was so terribly proved at Floing: 'At great distances our batteries have no chances against those of the enemy.' The superiority of trajectory almost follows. At 1,600 metres the Prussian breech-loader scores a column of infantry (or the ground) for 18 to 19 metres, while the French muzzle-loader only touches a line of 11 to 12 metres long—an advantage of from 20 to 26 ft. in favor of the breech-loader.

Effect of Projectiles.—The Prussian breech-loader of 4 shells on an average 40 *eclats*, of 6 ditto 35 *eclats*, as against the French muzzle-loader, 24 and 22 respectively. The grape practice of both is defective—a disadvantage not of such great importance in these days when infantry fire is so deadly at long distances, and cavalry charges and attacks on guns all but *hors de loi*. M. Littenant prefers the Prussian percussion fuzes to the French time fuzes. If he saw both used in action he could cite examples to justify his preference.

Range of Projectiles.—The Prussian breech-loaders of 4 and 9 give extreme ranges of 4,000 to 4,200 metres. The French muzzle-loaders of 4 and 12 give maximum ranges of 3,200 and of 3,000 metres.

Mobility.—The Prussian 4 weighs 1,550 kilogrammes; the 6 weighs 1,782 kilogrammes; the French 4 weighs 1,293 kilogrammes, the 12 weighs 1,937 kilogrammes.

Torpedoes.—In bringing before our readers, in as few words as possible, a short history of the torpedo, we shall show in what degree these weapons have as yet proved most effective, and also give a brief outline of their construction. We think it was in 1803 that a man named Fulton proposed to Bonaparte an infernal machine, which he promised should have the effect of destroying any ship afloat in a few seconds. He was allowed to make an experiment. The first was successful, but the next attempt failed, and the Emperor refused to countenance him further. The Crimean war was the next occasion in which torpedoes appear to have been used. But neither in the Baltic nor Black Sea did the allied fleets receive any serious damage from them. From this time to the late American civil war, little seems to have been done. The Confederate States had an extensive seaboard to protect, and were much crippled through want of war *materiel*. In this instance, in an incredibly short time they proved that they had created a most efficient mode of defence, and torpedoes seem here to really commence. Hitherto, little experience had been gained, but now the sinking in a few seconds of some of the enemy's heaviest ships was the best proof of success. This success was real, as not only was the attacking ship sunk, but in doing so it had the effect of itself creating an obstruction; the enemy had to be extremely cautious in all future attacks, to guard against the disastrous effects of the hidden foe.

The earliest kind of torpedo consisted of an iron or wooden receptacle for the charge, which was fired by a slow match, the torpedo being placed against the doomed ship. We next come to the *demijohn* torpedo. This consisted of a small tub or iron cask, containing the powder, which was fired by what was called a friction tube, effected by means of a connection with the shore. But as the operator always ran a great risk, it was desirable to dispense with him and to construct the torpedo so that it should explode on coming in contact with any vessel. The most successful torpedoes, and which maintain their high character, were constructed either of half-inch cast-iron or else of strong oaken casks, bound with wrought-iron hoops. The charges averaged 50 lbs. of powder, and were fired by a mixture of sulphuric acid with

potassium. These ingredients were placed in contact with the charge, but in separate glass tubes, which were broken by means of a simple but ingenious communication with the exterior of the torpedo. These torpedoes were most effective when attached to piles or frames, which themselves formed obstructions in a channel.

We now come to the method of firing the charge by percussion caps. This also proved most satisfactory, and was much used by the Confederates in the James River, Charleston Harbor, and in Mobile Bay. The chief objection to it was the liability of its becoming useless through the attachment of marine worms, etc., as was proved on more than one occasion. We next come to firing the charge by friction. This mode, for simplicity and certainty of firing, bears favorable comparison with any other known method. The composition forming the fuse-head is made of materials producing one of, if not the most sensitive compounds. The fire created by this fuse is conveyed to the powder by means of a rapidly burning composition placed between the fuse and the charge.

We would lastly refer to the torpedo fired by means of electricity, either by the incandescence of wire, or by the direct magneto-electric current. But we cannot speak so strongly in favor of this method of ignition, especially when we consider the simplicity and effectiveness of explosion caused by "percussion" or by "friction." And there is little doubt these two latter plans will for a long time prove to be the most efficient. Respecting the amount of charge used, it has been proved by actual experience that 50 lbs. of powder may produce the most disastrous effects. Few if any vessels escape foundering on the explosion of such a charge under them. It has been proved to be a great mistake to use too large a charge, for this simple reason—the receptacle which contains it is seldom made strong enough to resist the force generated by the entire ignition of the powder; so that often the explosion is premature, as proved by the unburnt powder blown into the water.

FIELD ARTILLERY.—The following very sensible remarks upon the subject of field artillery are from the "Delhi Gazette:"

"We promised, in a former number, to revert to this subject, having somewhat more to say on heavy artillery and large-bore guns. But our remarks to-day must be on field artillery and light guns, having been led thereto by the recent essay on furious driving of Royal Horse Artillery guns, as published by one of the Inspectors General of Royal Artillery. We confess to having seen and felt a thrill of childish delight when a battery of Royal Horse Artillery has galloped past the flagstaff by half batteries at close intervals; eighteen horses abreast whirling three light guns passed us with the rushing noise and nearly the velocity of a rocket. We confess we should be sorry to see this dash taken out of our Royal Horse Artillery, and the arm brought down to the quiet, tame, necessary jog-trot of a field battery having heavier guns. Moreover, we see no reason for this *elan* being taken out of the Royal Horse Artillery, as we can find but three elements of danger in this pace, separate and over and above those attending all mounted men's necessarily quick paces, and we will here mention them as they appear to us remediable. 1st. Then, why should a body of men (called detachment) ride immediately in front of the guns; so that should man or horse fall, as at Morar, over him or it the guns must go? We are confident no artillery officer would place his detachment thus were it not so laid down in books of drill for purposes of show; we can call to mind one only use of this order, and that is of occasionally masking the guns and making an enemy suppose it is cavalry without guns. 2d. Why should two unfortunate men be stuck on the gun limbers? They are literally sitting on small magazines of gunpowder! We believe many more ruptures and other injuries and accidents are sustained by 'limber men' than by the single riders in the detachments of Royal Horse Artillery. No one can conceive who has not tried it, the misery of sitting on a cart without springs, and being taken *nolens volens* and at all paces, not over a smooth parade, but over hillocky ground with an occasional ditch to jump of a foot or two in breadth; any of our readers may try it by going across country in an *ekka*, and even then they will have the best of it. The use urged for this absurdity is that the limber men can dismount and get the gun more quickly into action than can the mounted men of the detachment, whereas it is very doubtful if there is more than a quarter of a minute of difference in favor of the limberman, and that can scarce compensate for the risk of life and limb; while many a Royal Horse Artillery captain must feel hampered and dare not go over bad country which he might otherwise do had he all his men mounted on horses. It may also be urged on the score of economy, that two men more are trotted into the field with three horses less. This we would, with all deference to our military friends, urge is a very questionable gain? We would ask, if the seats of our limbers are full, how can you in action carry off a disabled carriage or men? Or, again, if your team horses are knocked over and you replace them from the detachment, where do the men go? The last remark we have to make is on the adoption of what is called close 'intervals;' why three or six carriages should be driven abreast at only a yard apart, we cannot think, except it be when there is no room for the guns on any particular ground to manœuvre at greater (intervals) distances from each other, which seems to be a manœuvre fraught with unnecessary danger. We challenge discussion on these three points: 1, detachments front; 2, limbermen; 3, close intervals. We think they may all three be beneficially done away with, and we, with all due respect to opinions of the Inspector General, should be sorry to see the day when our far-famed Royal Horse Artillery do not go 'the pace,' and cannot go across any country where they are required to support our cavalry in their charges, or to lead the van of the army. The present Inspector General of Royal Artillery is too keen a Horse Artillery man to recommend any step that would take anything from the *esprit* and dash of this noble right arm of the service."

THE "Glatton," 2, double-screw turret ship, armor plated, 2,709 tons, building in Chatham Dockyard, is making very satisfactory progress, more hands having been lately placed upon her, and it is expected that she will be ready to be floated out of dock this month in a very forward state. A large number of men are employed upon the turret, in which will be placed the immense guns with which the ship is to be armed. The breastwork of the turret is nearly completed, but the turret itself is only being prepared for the ar-

mor plates. The armor used for the "Glatton" will be of unprecedented thickness The armor of the breastwork of the turret is formed of 12-in. plates, but the turret itself will be protected with armor no less than 14 in. thick, the heaviest plates ever yet manufactured for our ships of war. The breastwork of the turret, the armor, the teak backing, and the inner iron skin will be nearly 3 ft. thick. The plating of the broadside of the ship is completed. Amidships the armor is 12 in. thick, but is reduced to 10 in. fore and aft. The armor plates for this formidable ship have been supplied by the Camell Ironworks Company, at Sheffield. The hurricane deck is in course of construction, and the whole work of building the ship appears to be making rapid way.

Some time has now elapsed since the ocean-cruising turret frigate "Monarch,' was inclined at Portsmouth to ascertain the exact measure of her stability, and the calculations made from the data then obtained have now been concluded and deposited with the department of the Controller of the Navy. It is reported that these calculations prove the measure of the "Monarch's" stability to be so much less than had been anticipated previous to this trial, that it is very possible a determination may be arrived at to reduce the ship's masts and spars, remove the hurricane or spar deck, and redistribute some of the weights stowed on the turret deck. After the dreadful experience in these matters gained from the foundering of the "Captain," it is fully expected that the First Lord of the Admiralty will relieve the public mind of anxiety as to the seaworthy capabilities of all the heavily armored and armed ships of her Majesty's navy, by making public the results of the calculations made from these inclining experiments.—*Mechanics' Magazine.*

A greater tonnage of iron ships is now in course of construction on the Humber than at any previous time in the history of iron shipbuilding. Messrs. C. & W. Earle have on the stocks in their yard seven large steamers—one of 2,000 tons, for a London house; four 1,800 tons each, for Messrs. Wilson, Sons & Co., Hull, the owners of the Wilson line; and two of 2,000 tons each, for Messrs. Norwood & Co. Messrs. Humphrys and Pearson have four large vessels in course of construction, and at both yards orders are in hand for other ships which will be laid down as the stocks are cleared of those now building. On Saturday, Messrs. Earle launched from their yard the largest steamer ever built at Hull. This vessel, which has been built for Messrs. J. Moss & Co., of Liverpool, was christened the "Canopus" by Mrs. Oswald Earle, of Liverpool, on behalf of Mrs. R. J. Moss, of Alexandria. The "Canopus" is intended for the trade between Liverpool and Alexandria. She is 400 ft. long, 37 ft. beam, and 27 ft. 9 in. deep. Her gross tonnage is about 3,000, and her actual horse-power from 1,500 to 1,600. The vessel left the stocks amid the cheers of thousands of spectators, who greatly admired her beautiful appearance on the water.—*Mechanics' Magazine.*

Bronze Guns.—The Belgian Government has made a series of highly important experiments with bronze guns. Two guns in the hands of the committee endured respectively 2,673 and 1,362 rounds. Several methods are employed for giving the guns greater hardness and tenacity.

ENGINEERING STRUCTURES.

Hoosac Tunnel—East End.—About 1,500 lbs. of dualin, in cartridges ready for use, reached here from Neponset ten days since, being the sixth attempt to supersede nitro-glycerine. The inventor of this compound arrived on the 28th ult., for the purpose of superintending its application in person. As this parcel had been specially prepared for the purpose, guided by the results of five previous experiments at various points of the tunnel, "great expectations" were raised as to the results. One of the slopes then being operated upon by nitro-glycerine and having a burthen of 8 ft., which was being thrown down every blast, bottoming every hole, was offered for the experiment. Similar charges of dualin were substituted for nitro-glycerine; the dualin was utterly unable to move the rock—the inventor asserting that this failure arose from the cold weather having affected the compound, the charges were thereupon warmed, but with no better result. Some charges were now inserted in holes having a burden of 2 ft., instead of 8; these removed the rock, but as powder would have done the same work, this was not deemed a success. Meanwhile some 400 lbs. of dualin were teamed to the central shaft, but as the results of three days' blasting at the east end were reported of "no account," this has not been used. We believe the results now attained with nitro-glycerine at the east end, and above described, viz., taking out the roof full width of the tunnel with a single series of seven drill holes having an 8-ft. burden, and bottoming every hole, indicates admirable direction of the work and argues well for the speedy completion of the tunnel. Progress during November, 133 ft.

WEST END.

Well No. 4, Messrs. Hocking & Holbrook have commenced using nitro-glycerine in their sub-contract, for the purpose of removing the rock preparatory to putting in the brick arch at that point; their first blast of nitro-glycerine in five holes, was tried on Monday with satisfactory results, and hereafter they intend to substitute it for powder, except in trimming. It seems to produce less jar, and it is anticipated will be less injurious to the brick work that is completed, than blasts with powder, besides expediting the work and saving money. 63 ft. of brick arch were completed during the month ending November 30.

WEST SHAFT.

The progress of the heading at this end, we understand, during the month of November, has nearly equalled that attained at the east end. When it is remembered previous to the present contract 40 ft. was more than average at this point, the progress (130 ft. during the past month) is very satisfactory.

CENTRAL SHAFT.

The advance made in the two headings just opened during the past month, was 76 ft. Considering that this rock has to be twice handled and then lifted over 1,000 ft. to the surface, such progress by hand drilling is very extraordinary work; but as Mr. Walter Shandley has been on the ground during the month, all the time, this may afford the clue how it is the headings are being driven at such a rate, by hand drilling.

Recent Visit to the Great Tunnel through the Alps.—The tunnel, as Professor Anstead has stated, will perforate the crest of the main

chains of the Alps, nearly midway between Mont Tabor and Mont Cenis, passing nearly under the summit of Mont Frejus. The operations of the tunnel involves a direct cut through a series of rocks on a line whose depth below the surface was almost at once very considerable. Owing to the form of the ground and the rise of the mountain, the depth was 2,000 ft. at each end after 2,000 ft. of tunnelling. From this point, however, the depth increased very little from each end for a long distance. In the middle of the tunnel the depth below the surface is 5,400 ft., while the deepest borings for such works as mines and wells do not exceed 3,000 ft. The works have been carried on throughout with some regard to the great physical questions involved. Among these the temperature at various distances and depths beneath the surface was not the least important. Instructions were given to bore a large hole laterally into the rock for a distance of about 10 ft., at intervals of 500 metres, and determine the temperature of the rock by thermometers provided for the purpose. On the northern side this important experiment had been carelessly executed, but on the south side, especially towards the centre, some good observations had been made, and the result was somewhat startling. The last observation made at the time of his visit was at 6,200 metres (20,342 ft.) from the south end, at a depth of more than 5,000 ft. The result was 28 deg. C.= 80½ deg. F. This would reduce the increment to a degree Fahrenheit in more than 100 ft., the general increase being observed in mines to average a degree in about 60 ft. Here again, however, there was still something wanting, the mean annual temperature of the surface not being accurately known, and the depth from the surface of the stratum of permanent temperature never having been determined. With reference to the progress of the work of tunnelling, the Professor stated that on the 31st of last month there remained less than 2,000 ft. out of 40,000 ft. to pierce, and as the present rate of progress is about 500 ft. per month, it may be expected that the communication will be complete by the commencement of the ensuing year.—*The Artizan.*

NEW BOOKS.

THE ELEMENTS OF PRACTICAL PERSPECTIVE. By ELLIS A. DAVIDSON. London, 1870: Cassell, Petter & Galpin. For sale by Van Nostrand.

Mr. Davidson's name is so well known in connection with Messrs. Cassell & Co.'s useful technical manuals, that no further proof is needed of the character of this volume than the author's name upon the title-page. It forms a natural sequel to "Linear Drawing," the study of which is essential to gain a knowledge of the construction of geometrical figures before the student commences the more involved problems of perspective. For the same reason the treatises on projection also take a prior place in order that the pupil's mind may become familiarized with the true forms of objects as conveyed by the parallel lines of isometric projection, before he attempts to lay them out in true perspective.

By very easy steps Mr. Davidson takes his student from the definition of the visual angle to the projection of figures at first elementary, afterwards more difficult, then through simple combinations of different forms representing familiar objects, until he takes leave of them with a brief chapter on the projection of curves. The experience of many years' teaching of pupils has given Mr. Davidson special opportunities of learning how to convey the information he desires to impart in the simplest and most effective manner, and we believe that no student will read his book in vain. We can cordially recommend it as being thorough so far as it goes, and we would recommend its being followed by another treatise investigating the subject still further. Such a book would be well received by pupils. It is of course too much to expect that within the limits of a small and cheap book, such as this manual is, any examples of drawing are given which the student can follow; the diagrams are merely exercises for him to work out, it being assumed that he has already learned the use of the drawing pen and compasses.—*Engineering.*

DRAWING FOR CARPENTERS AND JOINERS. Containing a Description of the Construction of the Subject of each Study and the Method of Drawing it; with Elementary Lessons in Freehand and Object Drawing. With 250 illustrations and drawing copies. By ELLIS A. DAVIDSON. London and New York: Cassell, Petter & Galpin. For sale by Van Nostrand.

We have here another of the excellent series of small technical manuals which has been in course of publication by Messrs. Cassell for some time past—a series which is calculated to do good service to the classes for whose use it has been specially produced. The particular volume of this series now before us is intended as a sequel to the manual on "Building Construction," by the same author, which we had occasion to notice favorably a few months ago. The book commences with an elementary chapter on linear drawing by means of instruments, and then goes on to treat of freehand drawing, drawing from solid objects, wooden bridges, linear drawing for carpenters, the development of roofs, drawing for joiners, mouldings, staircases, and freehand drawing for joiners. In dealing with these various subjects, Mr. Davidson not only shows how the different examples are to be drawn, but he in most cases explains why the particular form or method of construction represented is adopted, and his book is thus something far more useful than a mere drawing-book would be. The work is one we can heartily recommend to the classes for whom it has been written.—*Engineering.*

THE PRINCIPLES OF MECHANISM AND MACHINERY OF TRANSMISSION. Comprising the Principles of Mechanism, Wheels and Pulleys, Strength and Proportions of Shafts, Couplings for Shafts, and Engaging and Disengaging Gear. By WILLIAM FAIRBAIRN, Esq., C. E., LL. D., F. R. S., F. G. S., Corresponding Member of the National Institute of France and of the Royal Academy of Turin; Chevalier of the Legion of Honor, etc. Philadelphia: Henry Carey Baird. For sale by Van Nostrand.

From the imposing array of scientific honors appended to the author's name, our readers might be led to suppose that this work was written for others than practical mechanics, but no greater mistake could be made than such a supposition. Mr. Fairbairn, though eminently scientific, is one of the most practical of men, and he knows to a nicety the wants of practical men. This book is

written in the plainest and most concise style, and may be read with profit by those to whom algebra and geometry are unsealed mysteries. There are a few algebraic formulæ in the book, but the larger portion is written in plain English. The work treats of a great variety of subjects included in the general classification given in the title and ought to be in every mechanic's library.

ETUDE SUR LA TOUR A GAZ ET A CHALEUR REGENERE DE M. SIEMENS. Par M. F. KRAUS, Ingenieur des Mines, Professeur de Metallurge a l'Universite de Louvain. 5 planches. Louvain, 1869. For sale by VanNostrand.

AN INTRODUCTION TO NATURAL PHILOSOPHY. Designed as a Text-Book for the Use of Students in College. By DENISON OLMSTEAD, LL. D. Second revised edition, by E. S. SNELL, LL. D. New York: Collins & Brother. For sale by Van Nostrand.

The new edition of this book will be welcomed by instructors who are familiar with the many excellencies of the older editions. As a text-book for beginners in Mechanics, it has held the foremost place in American colleges and academies for many years. The expositions afforded in the first chapters in the book of the laws of motion, the laws of falling bodies, the parallelogram of motions and forces, and the centre of gravity, are rarely if ever equalled in the text-books.

The work contains as full a course of Physics as should be required in any but the technical schools; and for students preparing for the scientific schools, whether by aid of instructors or without it, there is no better initiatory training for the extended courses of Weisbach or Rankine, than is afforded by Olmstead's Philosophy.

Prof. Snell's revisions have increased the value of the work. A chapter on Heat is added and the subjects of electricity, magnetism, and electro-magnetism are re-written. These several subjects, as presented, are fully up to our present knowledge of the topics; the number of illustrations is largely increased, and the typography is all that could be desired in a text-book.

AN ELEMENTARY COURSE OF HYDROSTATICS AND SOUND. By RICHARD WORMELL, M. A., B. Sc. Fcap, 8vo. pp. viii. and 146. London, Groombridge & Sons, 1870. For sale by Van Nostrand.

This little book is "designed for the use of schools, colleges, and candidates for University and other examinations." In such a work it would of course be out of the question to look for novelty of matter; by the nature of the case, to praise the author's originality would be to cast a doubt on his accuracy, and, while inaccuracy would be inexcusable, no merit can be claimed for its opposite. Hence, in trying to form an estimate of a book like this, we are inevitably led to consider whether the subjects treated are arranged in a simple and natural order; whether the exposition of principles is clear and logical, the really fundamental matters being kept constantly and prominently before the student's mind, and special consequences and applications grouped about them in such a manner as to show distinctly their mutual connection and dependence; whether, in short, the book is scientific in treatment as well as in subject. We are sorry to say that, in these respects, our judgment of the work before us is by no means favorable. We should expect a student, instead of acquiring from it ideas which are capable of growth and expansion within his own mind, and being led towards the conception of the organic connection of all scientific truth, to conclude that science—or at least hydrostatics and acoustics—consists of a series of propositions which it is his duty to "get up" and write out on the first opportunity in answer to examination-questions. The least satisfactory parts of the book are the explanatory and descriptive portions, and especially the 22 pages at the end, devoted to sound. The author says in the preface that "the whole contains all that is required on these subjects [hydrostatics and sound] for the B.A. and B.Sc. degrees of the University of London." If this is true as regards the latter subject, it is more to the discredit of the University than to the credit of his book.—*Nature.*

MISCELLANEOUS.

WILL our excellent trans-oceanic contemporaries, the "Building News" and the "English Mechanic," please give us credit when they borrow our translations or contributed articles?

THE GREAT AMERICAN LAKES.—The following statement regarding the dimensions and altitude of the great American Lakes will serve to correct the errors of a paragraph in our last volume:

	Area sq. miles.	Elevation.
Lake Superior	32,000	600 ft.
" Huron	20,000	579 "
" Michigan	22,000	579 "
" Erie	9,600	565 "
" Ontario	6,300	232 "

The area drained by these lakes according to Professor Silliman is 335,515 sq. miles, and the average quantity of water passing over Niagara Falls is 22,440,000 cubic feet per minute.

A SURVEYOR IN 1678.—The following is an exact copy of an advertisement which appears in a publication dated 1678:—

"James Ward, of Langley, near Windsor, Surveyor, can perform Artificially the Conveying of Water, either by Channels or Cutting New Rivers (in any places where 'tis possible to be done): He can also build new, or repair old Bridges over Rivers, and undertakes the new building or reparation of Water-mills, or any water-works; the hanging of Bells, Dyalling. Surveying of Lands, Gaging of Vessels, &c. He has lately invented an Engine for the pumping of Water, which by the assistance of one man (only) will pump two Tun of Water in one Minute (as has been experimented in St. James's Park) and is of excellent use in the Floating or Draining of Grounds, Fen-Lands, Tin-Mines, Ships, also for Brewers use, &c. This Engine will raise water 100 foot high and upwards. He hath exceeded all that hath been done of this kind.—*Building News.*

INFLUENCE OF CANNON-FIRING UPON RAIN.—M. Charles La Maout, apothecary at Saint Brieuc, in France, has published some interesting observations on the influence of artillery-firing upon the fall of rain and the force of the wind. During the siege of Sebastopol, soon after the firing commenced the sky became obscured with clouds and

a fine rain began to fall, which was sometimes followed by a deluge or whirlwind. Immediately, and as a consequence of the condensation, the mercury in the barometer rose in proportion to the violence of the cannonading. A chart of the movements of the barometer afforded a good indication of the bombardment. The author then proceeds to show how rain could be produced at will by a judicious discharge of artillery. There is no doubt that this would be a better use of cannon than the wholesale slaughtering of men, but whether rain could be produced at will in this way is another question. There is some confirmation of the theory in the fact that a violent rain fall has attended the recent engagement of troops near Metz, in France. The subject is one quite worthy of investigation, and if it were found to be expedient the proposition of the author to establish meteorological stations with suitable artillery ought to be carried into execution.

THE COST OF WAR.—In a Parliamentary paper printed by order of Parliament in 1828, which contained the result of the labors of the Select Committee on Public Income and Expenditure, some tabular statements are given showing the difference between the public receipts and expenditure during various periods, and among others for the ten years of war which ended with the peace of Amiens in 1802, and for the fourteen war years which terminated with the peace in 1816. The following is an abstract of this statement from the first of these periods :—

Total expenditure		£447,812,900
Total income from taxes		258,659,000
Excess of expenditure over revenue		£189.153,000
Total sum raised by new loans, etc.		£380,997,000
Of this sum there were applied to—		
Redemption of old debt	£180,346,000	
Lent to Austria	4,600,000	
Discount and other charges of receipts	2,416,000	
		£187,362,000
		£193,634,000

Leaving a balance to the Exchequer on January 5, 1802, of a trifle over 9,000,000.

The abstract for the 14 years ending January 5, 1816, is still more remarkable—

Total expenditure		£1,059,683,000
Total income from taxes		823,354,000
Excess of expenditure over income		£236,329,000
To meet this deficiency and to pay off portions of the existing debt, there was raised by new loans		£900,107,000
Of the sum so raised there was applied—		
To pay old debt	£651,952,000	
Lent to the East India Company	2,500,000	
Discount, etc.	28,877,000	657,339.000
Total sum applicable to meet deficiency of income		£242,767,000
Leaving a balance in hand on January 5, 1816, of a sum of		£15,500,000

The total excess of expenditure over the ordinary income of the country during the 24 years of war, from 1692 to 1816, amounted to the enormous sum of £125,482,000.

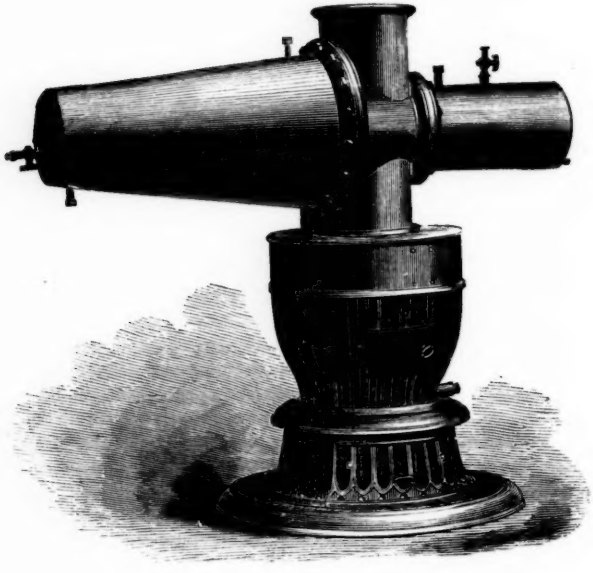
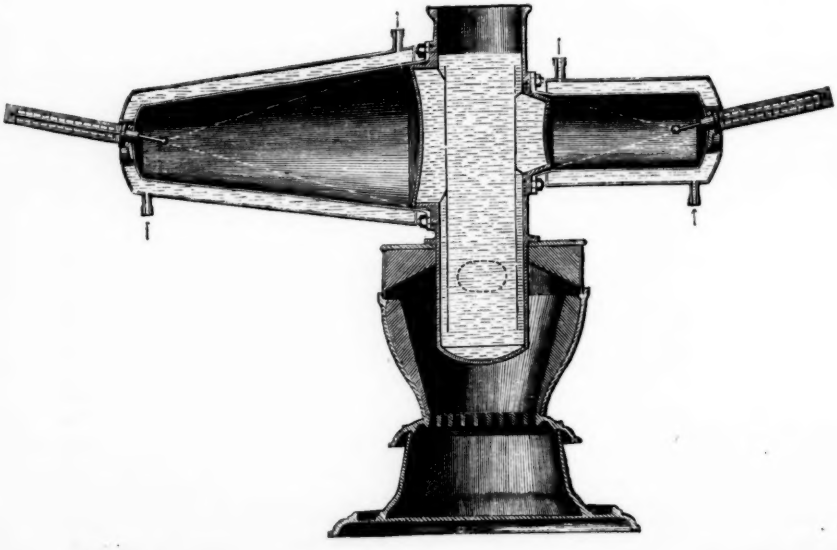
REMARKABLE ENGINEERING OPERATION.—The recent change of grade in Fifth avenue, between Sixty-eighth and Seventy-second streets, laid bare the two large 3-ft. iron water pipes which supply the city below Central Park, and rendered it necessary for them to be lowered to the depth of about 4 ft., in order to protect them from frost and from injury by the constant passing of vehicles. As one pipe is not of sufficient capacity to supply the wants of the city below Central Park, it was decided to prepare a bed on the west side of the avenue as a temporary resting place for the pipes, while a proper trench, 12 ft. wide and from 1 to 4 ft. deep, could be excavated for them beneath the line they had occupied. This was no easy task, as the pipes were then laid in a trench cut through solid rock, and, before they could be moved an inch, one side of the trench had to be blasted and removed with the utmost precaution. When the temporary bed, some 8 to 10 ft. wide, was properly prepared, the Croton mains, each about 1,000 ft. in length, were slipped sidewise on wooden blocks with great care, so as not to disturb any of the joints.

The magnitude of this task may be inferred from the fact that every foot of the pipe, including the water contained therein, weighs about 1,500 lbs.

After the pipes were shifted to the temporary bed, a trench 12 ft. wide and from 1 to 4 ft. deep, was excavated through the solid rock along the centre of the avenue. Into this the pipes are now lowering without interrupting the flow of water through them. The pipes were laid in 1840, and appear to be very little corroded, and the hemlock blocks from the northern part of the State, upon which the pipes have rested for the last 30 years, are as sound to-day as they were when buried with the pipes.

NEW SOURCE OF MINERAL WEALTH IN NEVADA.—The Commissioner of the General Land Office is in receipt of samples of potash salts from the newly discovered and extensive deposit in Churchil county, Nevada. As a new source of mineral wealth connected with the development of chemical industry the subject is of public interest. Not only do the salts furnish the purest potash, but the lye therefrom is available for bromine, the price for which since 1865 has fallen to one-fourth of its former cost. Hitherto the sources of bromine have been the mother of lyes, resulting from the evaporation of sea water in Southern France ; the kelp or varec (a species of algæ) of Nether Bretagne and England, and the water of the Dead Sea. The latter contains already, at a small depth, 0.7 per cent. of bromine, which is separated by means of bichromate of potash and muriatic acid.

Since the discovery of the potash deposits in Strassfurt, all these sources have been unavailable. The lyes of chloride of magnesium, a product in the manufacture of the potash salts contain from 0.15 to 0.25 per cent. of bromine, which is extracted by subjecting them to distillation with peroxide of manganese and muriatic acid, and refining the obtained bromine in the ordinary manner. The Strassfurt bromine is nearly chemically pure ; it supersedes the English and French, and has pushed them already from the market. In the manufacture of aniline colors it has become the substitute for iodine, and is already in extensive use as a disinfectant in the European hospitals, owing to the fact that it affects the lungs less than chlorine.

CAPTAIN ERICSSON'S SOLAR PYROMETER.

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